October/November 1988

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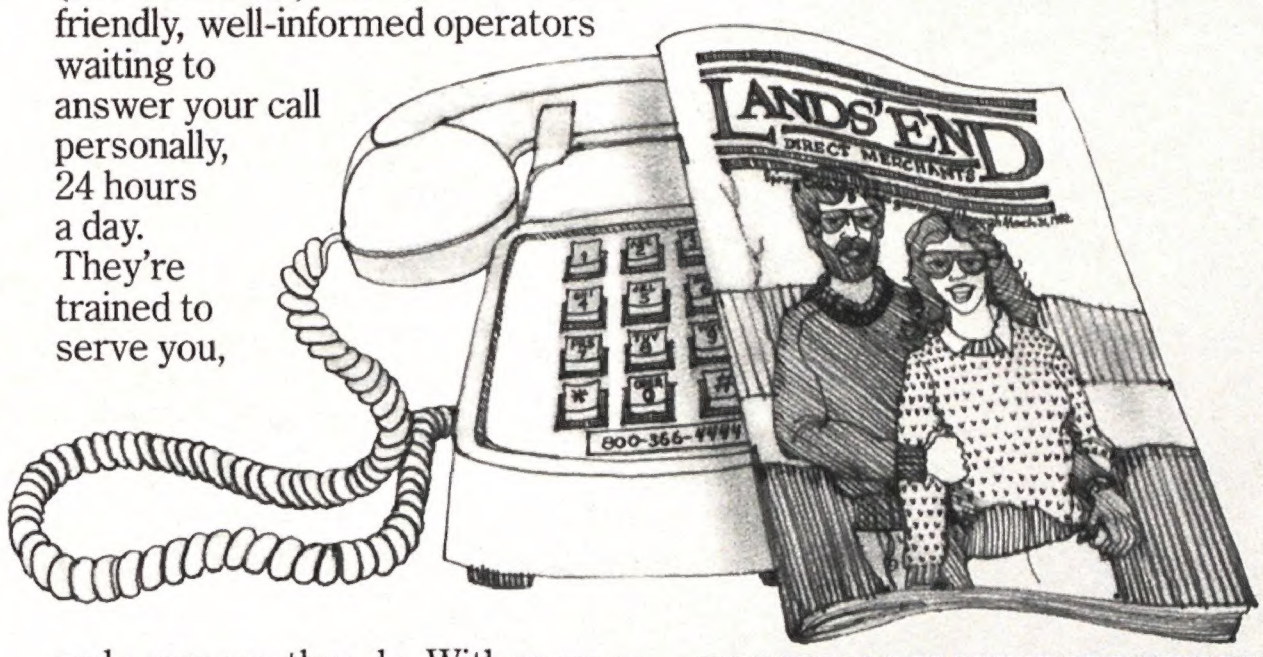

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October/November 1988
Volume 3, Number 4

AIR&SPACE
Smithsonian

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LORD NELSON AND MILSTAR

Trafalgar, 1805, the battle that was to lead t
the eventual undoing of Napoleon, was won be
cause Admiral Horatio Nelson had a secret weapo
signal flags.

The technique of communicating over long di
tances by coded flags had only recently been invente
by the Royal Navy. It revolutionized naval warfare.

The system enabled the British ships to cove
vast expanses of ocean, looking for the enemy, whil
remaining in close contact with the fleet commande
It also allowed tactical flexibility once battle had bee
joined. Other navies were bound by rigid battle plan

agreed upon in face-to-face councils long before the first broadside. They were confounded by the British and their talking flags.

The result of Trafalgar, and in large part this communications system, was that Britain enjoyed undisputed rule of the seas and over a century of relative peace; a *Pax Britannica.*

In modern warfare, command, control, and communication are as decisive factors as they were two centuries ago and even more complex. History is peppered with anecdotes of communication breakdowns leading to fiasco. It has been called the fog of war.

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Preserving Space History

One of the most challenging and inspiring technological achievements of the 20th century has been mankind's venture into space. Public appreciation of this undertaking has focused for the most part on the exploits of the space explorers and on the creators of their spacecraft. But many less visible contributions were equally important—in particular, the government's conception, organization, and implementation of this endeavor, drawing on the scientific, technical, and managerial resources of industry and academia.

While cooperation between the public and private sectors has been a significant part of our space heritage, most of the early records of this partnership remain scattered among the participants. To preserve these records, the Museum has inaugurated the Glennan-Webb-Seamans Project for Research in Space History. Named for three key administrators of NASA—T. Keith Glennan, the first NASA administrator; James E. Webb, his successor; and Robert C. Seamans, associate and deputy administrator during their tenures—this project is the first systematic effort to unite, assess, and promote the study of these rich and diverse sources.

The GWS Project encourages coordination among these varied repositories of space history as well as their collaboration in preservation and research. One such recent undertaking—between the Communications Satellite Corporation (COMSAT) and George Washington University in Washington, D.C.—demonstrates the challenges and scholarly opportunities such efforts can offer space historians.

This year, as part of the celebration of the 25th anniversary of its founding, COMSAT decided to make a key collection of corporate records—the papers of Joseph V. Charyk, its first president and later chief executive officer and chairman of the board—available for research. To ensure professional care and handling, COMSAT donated them to the university's special collections department, where they will be readily accessible to researchers.

The papers should attract a great deal of interest. The creation of COMSAT, incorporated in 1963, was surrounded by controversy. The launch of Sputnik had created intense public concern about the United States' technological capabilities. As with the Apollo program, President Kennedy and the Congress saw the development of a communications satellite system as an urgent objective. A major issue was whether the government or the private sector should undertake the program. In 1962 a legislative compromise resulted in the distinctive concept of COMSAT, a corporation chartered by the government but owned by private shareholders.

COMSAT's principal mandate was to quickly establish an international communications network with satellites. While meeting the escalating needs of international communications, such a system would help renew international prestige by demonstrating America's mastery of space age technologies and its willingness to share practical benefits.

COMSAT's donated papers constitute a rich store of correspondence, corporate materials, memorabilia, and other documents that provide a rare view of the daily work of the aerospace community. To stimulate scholarly interest in its history, COMSAT is also supporting a fellowship through the GWS Project. Through its preservation efforts, the project will assist historians in relating these papers to other relevant resources.

Prior to the project's launch, there had been little active outside encouragement to preserve the records of aerospace corporations' role in space and few venues in which these records could be made available to researchers. This collaborative approach is an important way to meet this need. It is through the preservation of such collections that we will gain a deeper appreciation of our dynamic and complex space heritage.

—Martin Collins is director of the Glennan-Webb-Seamans Project for Research in Space History.

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Letters

Missed Opportunity

In her article "My Friend, G.M." (August/September 1988), Elinor Smith didn't mention that Charles Lindbergh actually came to New Castle, Delaware, to have Bellanca build him an airplane for his Atlantic flight. However, Bellanca refused the order because he was already building such an airplane for Clarence Chamberlin. Lindbergh knew that the airplane Bellanca was building could indeed do the job. That's why he put the pressure on Ryan in California to build the *Spirit of St. Louis* in an amazing 30 days. If Chamberlin and his Bellanca had gotten off the ground before Lindbergh . . .
George Frebert
Dover, Delaware

Editor's reply: Actually, it was Bellanca's backer, a young, publicity-conscious millionaire named Charles Levine, who threw the wrench into the works of the Lindbergh sale. Levine offered to sell the airplane to Lindbergh at less than he felt it was worth—$15,000 instead of $25,000—with the provision that the company determine who would fly it. Not surprisingly, Lindbergh took his business elsewhere.

In her otherwise excellent article, Elinor Smith states that "the *Columbia* crossed the Atlantic and exceeded Lindbergh's distance record by flying beyond Berlin." Actually, the *Columbia,* with pilot Clarence Chamberlin and owner Charles Levine, ran out of gas and landed in a German wheat field near the Eislebe, about 100 miles short of Berlin. However, after a flight of 3,911 miles they really did exceed Lindbergh's distance record by almost 300 miles.
Chandler A. Robinson
Fort Worth, Texas

Blowing Hot and Cold

Congratulations on an excellent summary of the wind energy industry's current status and future hopes ("Harvesting the Wind," August/September 1988). Now that the greenhouse effect—global warming caused by fossil fuels—is becoming a serious scientific and public concern, wind energy may finally be able to claim its rightful place in our nation's energy mix.
Thomas O. Gray
Executive Director,
American Wind Energy Association
Arlington, Virginia

Berl Brechner, in preparing "Harvesting the Wind," surely did not interview any of the residents of or visitors to the western end of California's Coachella Valley.

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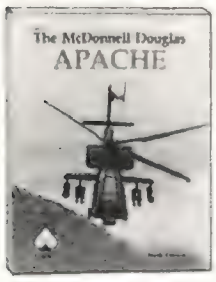

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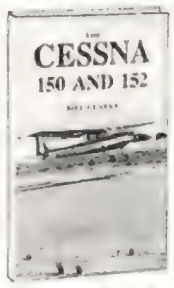

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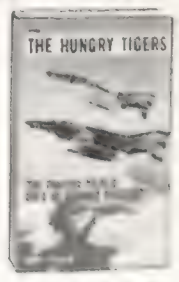

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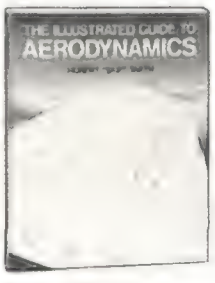

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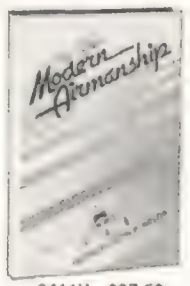

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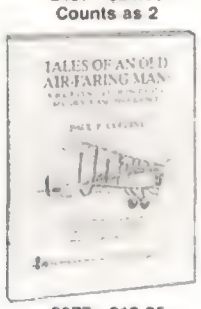

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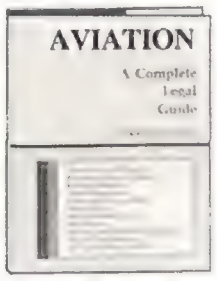

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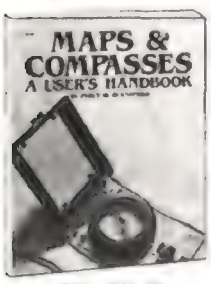

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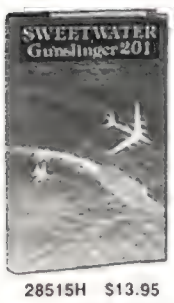

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Otherwise he would have reported that, except for their investors and builders, the windmills are despised by everyone. They have completely destroyed the beauty of the desert north of Palm Springs, especially that of the hills at the mouth of the San Gorgonio pass.

The cost of energy produced by these machines is far greater than that of any other source available, and the utilities must buy their output. Built only because of the tax sheltering they offered, they are not economically viable on their own.

Even on the windiest of days, few of the machines ever seem to be operating. Many of us wonder if they are even connected to anything. Brechner can have them.

Gene Costin
Los Angeles, California

No Lines

I was glad to see the Olympic skydiving mentioned in Soundings (August/September 1988), but I wish to make a correction. A person using a static line is a parachutist. A person who has progressed to freefall is a skydiver. The people involved with the Olympics are accomplished skydivers.

Jim Koontz
Tradewind Aerialists Skydiving Exhibition Team
Torrington, CT

Not Me

In the August/September 1988 issue the work of artist Robert Taylor is discussed in In the Museum. His "Duel of Eagles," a painting depicting a battle between Douglas Bader and Adolf Galland, is described as follows: "The ailerons on Bader's Spitfire have set their teeth into a hard right roll, and Galland's Me-109 is already following him." There was no such airplane as the Me-109. The 109 was designed by Willy Messerschmitt for Bayerische Flugzeugwerke A.G. The Luftwaffe referred to it as the Bf-109, as do aviation historians today.

The Bf-109 was one of the great planes, staying in production in some variant or another somewhere in the world for 20 years. The Luftwaffe put the first examples into service in 1936, and an updated version came off Spanish production lines as late as 1956. Altogether, approximately 35,000 were built.

Donald G. Kloenne
Hicksville, New York

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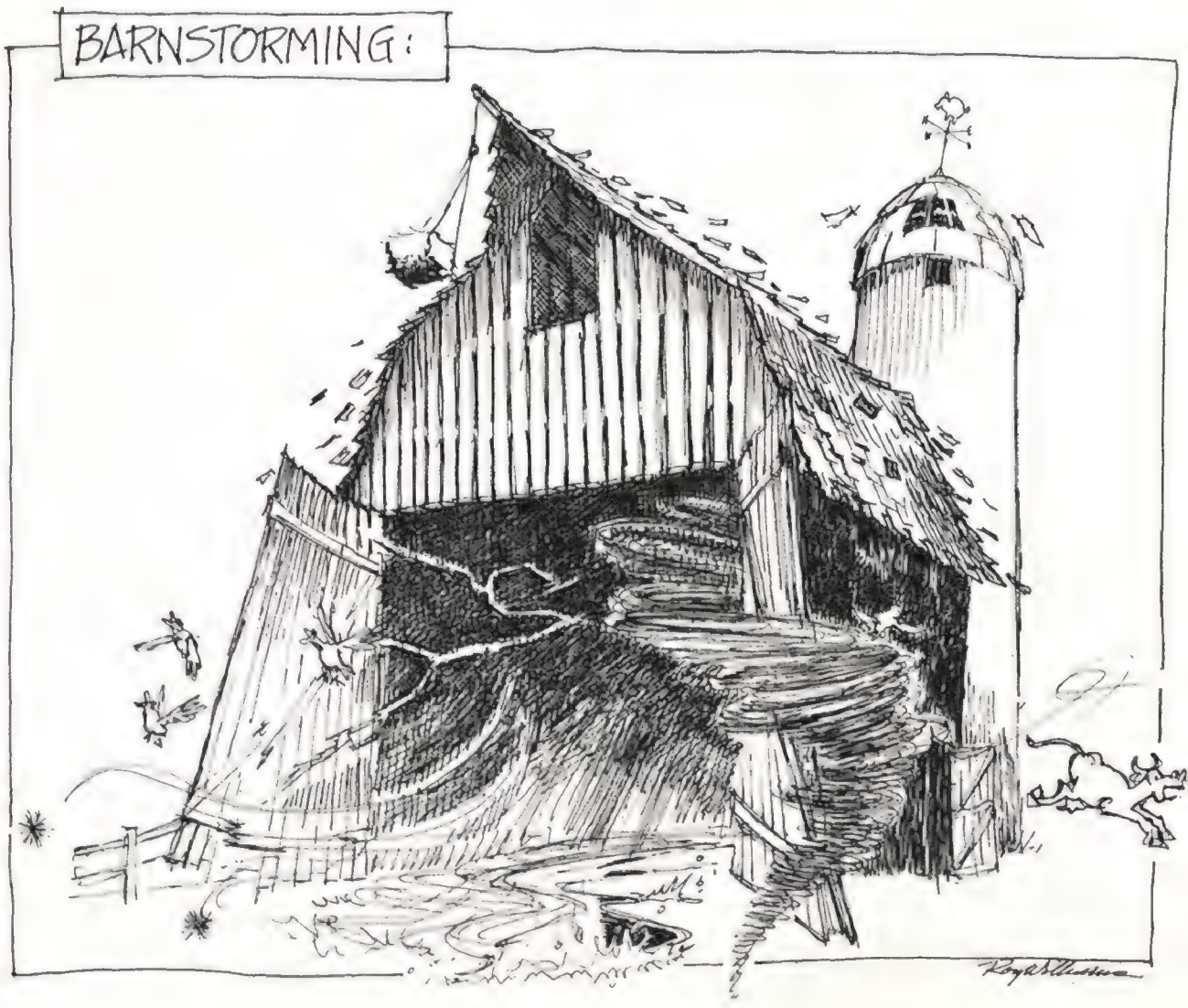

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¡Viva Carranza!

Caroline Sheen (2)

Friday the 13th of July, 1928, brought bad luck to aviators. According to the *Trenton State Gazette*, six airplanes crashed or encountered trouble, and 11 fliers died.

One of the victims was Mexico's premier pilot, Emilio Carranza, who departed New York's Roosevelt Field the previous evening for a nonstop flight to Mexico City. An hour later his Ryan monoplane crashed after being struck by lightning.

The 22-year-old army captain was recreating a goodwill flight Charles Lindbergh had made the previous year. Bad weather had forced Carranza to delay his departure twice. At 7:18 p.m. he got rid of the press by announcing another postponement, then took off into the gathering clouds. Blueberry pickers discovered the wreckage the next day in a remote corner of New Jersey's Pine Barrens forest. The Carranza story would have faded into oblivion had it not been for American Legion members who vowed to keep the pilot's memory alive.

Legend has it that local Legionnaires helped recover Carranza's body, which had already been looted of its Mexican army medals. Whatever its role 60 years ago, Post 11 in Mount Holly is today the keeper of the Carranza flame.

Originally, memorial services were simple: a few airplanes would fly over the crash site and drop flowers. Over the years the event has grown more elaborate. At this year's service, a U.S. Army band played the Mexican and American national anthems while a color guard, rifle squad, and bugler stood at attention. "This is an occasion full of warmth and significance," Brigadier General Jorge Espinosa told the crowd. "Captain Carranza, knowing the risk, took courage to fly nonstop from New York to Mexico City. But the Gods of Olympus, full of jealousy, crashed him here." For the next hour, representatives of Mexican and South American cultural organizations, veterans' groups, and the military placed flower wreaths at the base of a 10-foot obelisk, erected in 1931.

After the ceremony, everyone adjourned to the nearby Lumberton fairgrounds for hot dogs, corn, beer, and tortillas. Despite the muggy heat, the Ballet Folklorico Mexicano de Nueva York performed to music from a boom box, twining ribbons around a maypole, hoisting a papier-mâché boar's head dripping with fruit, and balancing beer bottles on their heads.

"It's not just a picnic," explained Clara Marcovich, who came down from Queens, New York, with her daughter and grandson. "It has everything: folklore and the Mexican roots we share with others who come. One day of the year, we feel we are all in Mexico together."

—Patricia Herold

Locked in Model Combat

"It's fast reflexes, instant, instinctive decisions, one man against another; it's maneuver, retreat, attack, strategy," shouted control-line combat pilot Bob Carver as two tiny airplanes shrieked overhead. "It's the ultimate video game, except it's real."

Carver was one of 50 model builders who

Nick Gunderson (3)

had come to Snohomish, Washington, to demolish their aircraft in an annual kamikaze-style contest held for the 13th time on the last weekend in June. Named "Bladder Grabber" for the models' bladder-type fuel tanks, the meet is to model airplane flying what karate is to ballet.

In a meadow adjacent to Harvey Field's grass runway, two contestants danced in a six-foot circle, trying to avoid tangling their 60-foot control cables—and themselves—in a dogfight-by-wire. Occasionally the pilots collided like two outfielders racing backward for a high fly.

Scoring rules are simple: 100 points for slicing the eight-foot crepe paper streamer off the tail of an opponent; a "kill" for cutting the string that connects the streamer to the tail. Often the ear-piercing wail of the 1.5-horsepower unmuffled engines turning at 20,000 rpm was cut short by the abrupt *whomp* of a collision, which filled the air with a tiny cloud of styrofoam and balsa wood. Crashes are routine in combat flying at 120 mph, so contestants brought at least a half-dozen models each in order to have something to fly in the final rounds.

The models, mostly wings with stubby tails, were built to take punishment. The four-foot styrofoam wings were reinforced with balsa, carbon fiber, and fiberglass tape. Often one survived a collision and continued the fight with a chunk bitten out of a wing. The loss of an airframe is negligible compared with the loss of an engine, which costs $100 or more.

"You know you've been alive after you have flown a combat match," says Carver, the president of a stereo component manufacturing company that donated $11,000 worth of equipment to be divided among the top five finishers. After two long days and 152 matches, Steve Kott outflew and outlasted the competition. He returned to Wayne, Michigan, with five of his eight models still intact.

—Christian Weinreich

Oh Say Can You See?

The roar of a rocket lifting off the launch pad at Cape Canaveral can be heard 30 miles away. Within six or seven miles, shock waves shake the ground and rattle windows. Watching a shuttle launch on TV just can't compare to being there.

When NASA resumes shuttle flights this fall with the launch of *Discovery*, a record crowd of one million is expected to descend on the coast near Cape Canaveral. While technicians tighten bolts and seal O-rings, NASA and Air Force officials have been showing as much concern with the safety of launch spectators. In fact, their precautions may make public viewing of shuttle launches virtually impossible.

Last April Edward C. Aldridge Jr., secretary of the Air Force, wrote to NASA director James Fletcher warning of a potential "national problem" if another mission failed and showered debris over Florida's Space Coast. Aldridge suggested that public observation points be moved back, and NASA agreed.

The previous "impact line," beyond which the public was not permitted, was about three and a half miles from the Kennedy Space Center launch pads. The new guidelines will keep most spectators 10 miles or more from the launch pad. "It would eliminate any public viewing, for all practical purposes," says NASA news chief Dick Young.

Magna Charter

What's in a name? Plenty, in an election year, says Presidential Airways.

Bob Dole, Paul Simon, Jesse Jackson, George Bush, and Michael Dukakis all requested a charter aircraft from the Washington, D.C.-based airline, which displays the company name on the fuselages of its airplanes. According to Presidential's director of market development, John Wrightington, last February Simon was the first candidate to lease the only Boeing 737 the company has available for charters. Presidential considered applying a decal bearing Simon's trademark bow tie over the door. "But Simon wiped out so early that we never got to use the tie," says Wrightington.

Next in line for the 737 was Dole, and Presidential kicked around the idea of ordering a huge pineapple decal for the fuselage. When Dole dropped out, the idea got tossed.

Despite pleas from Jackson and Bush, the Dukakis campaign managed to reserve the aircraft next. "We had been advised not to lease to [political campaigns] because they don't pay their bills," says Wrightington, "but we've never had a problem."

Because of hectic campaign schedules, the Dukakis staff decided to forego airline food. Instead, the staff orders out for Kentucky Fried Chicken and Domino's Pizza—"a *lot* of Domino's," says Wrightington. "Someone on the plane sure likes pizza."

—Lois Romano

The Air Force, which for more than 20 years has been responsible for the safety of the surrounding area during launches from the Kennedy Space Center, has long considered the viewing limits too relaxed. It's conceivable, officials say, that an out-of-control rocket could head inland, endangering thousands of spectators and residents.

Implementing the guidelines could result in a perfectly safe launch but further dampen public interest. For years thousands of spectators have thronged to the cape, stopping along highways and sleeping in their cars in order to catch a glimpse of a liftoff. But now the launch could lose its drama. Says shuttle enthusiast Mark Potts, "There's not much you can see from *three* miles."

—Matt Schudel

High-Rise Rescue

It's an urban nightmare—fire raging in the lofty reaches of a skyscraper and occupants trapped out of the range of ladders.

But Sidney Conn, spurred by the Las Vegas MGM Grand Hotel inferno that killed 84 people in 1980, is working on a solution: a hot-air balloon that can quickly scale the tallest buildings. Called LifeJack, it will carry up firefighters and bring down victims, all in minutes.

Since round balloons can't cling to square structures, LifeJack is cube-shaped, 35 feet on a side, and can butt up against a building. Tethered to high-speed winches, LifeJack will be controlled by operators on the ground. Firefighters and supplies will ride on a rigid platform atop the balloon. Built into the base is a U-shaped compartment that can carry 25 people. "They will simply push aside a flap and step directly into the compartment, perhaps from a window knocked out by firefighters," says Conn. He is still looking for a blend of synthetics to create a balloon that can withstand flames and the corrosive pollutants in smoky environs as well as contact with rough surfaces.

Uninflated, LifeJack will be towed in a small trailer behind a fire department vehicle and can be readied in less than 10 minutes. An internal Wankel engine will superheat air to about 600 degrees Fahrenheit, three times the temperature in a recreational balloon.

"This means LifeJack will have extraordinary lift and will rise like a shot," says Conn, president of LifeJack Inc. in Statesville, North Carolina. "We expect the device to ascend 1,000 feet—about the height of a 100-story building—in less than a minute and descend in less than two." It could climb at 4,000 feet per minute, but

Kim Barnes/Stansbury, Ronsaville, Wood Inc.

Conn says this isn't practical—"We're trying to save people, not scare them to death."

Conn expects the cost of a LifeJack to be around $300,000. "Aerial ladder trucks cost at least twice as much yet only reach up 15 stories or so," he says. "And helicopters are not only prohibitively expensive but also are treacherous to fly near burning buildings and may even fan the smoke and fire."

Conn has met with fire officials in Los Angeles and says their reaction was positive. "They said the best thing they have right now is air bags. But even under the best conditions, the chance of hitting an air bag at seven stories is remote." Glenn O'Ferrell, Statesville's fire chief, says the device is "a solution superior to anything we have now."

Conn initially feared that the Federal Aviation Administration would decree that the balloon was a standard lighter-than-air craft and therefore subject to a host of restrictions—including not being allowed to "fly" within 2,000 feet of buildings. "It took about two years of negotiation, but the agency recently ruled that LifeJack is a rescue device," Conn says. "That makes our life much easier."

—Tom Burroughs

Cessna Extravaganza

The face of the young pilot who greeted the flagman through the side window of the little Cessna was lit up like a kid's at Christmas. Sweating under an orange plastic hardhat, the flagman waved him to the next checkpoint and turned to face another Cessna just turning off the runway. Already, multiple lines of aircraft were stretching across the dusty acreage, spilling out people who shouted greetings to one another as they pounded tie-downs and tent stakes into the parched earth. Trucks rolled up and down the improvised taxiways, spraying water to minimize dust storms created by whirling propellers.

Dozens of Cessna 140s were converging on the small airport at Monticello, Iowa, in preparation for a mass formation flight on July 29 to the annual Oshkosh, Wisconsin fly-in. Some 7,600 two-seat Cessna 140s and the model's twin, the 120, were built between 1946 and 1951. Nearly half are still flying. Two years ago United Air Lines mechanic Jim Barker decided it was about time to beat the Cessna 170 club, which had arrived at Oshkosh a few years ago earlier in a flight of 76 aircraft. Barker, certain that 140 owners could top that, put out the call "88 in '88!" He got nearly twice that number.

In previous years the Monticello airport, under the management of Paul Elmegreen, had hosted the few 140s en route to Oshkosh from the West Coast, but the town had never seen the likes of this year's pilgrimage. On the last week in July airplanes were arriving from all over the country, even Alaska. "Welcome Cesna Pilots!" read an originally spelled banner in a window, and so it went up and down Main Street. The local pork growers threw a huge cookout in the hangar one night, and the beef growers equalled it the next. In the evenings, parents came out by the hundreds to stroll among the airplanes while pilots took the children up to peer at the town from a thousand feet.

Reveille came at 3:30 a.m. on a muggy Friday morning. No one had slept much, and now the aviators rose in the darkness to pack tents and say their farewells.

Ground handlers began the long process of forming two lines of aircraft for takeoff. Fifty Cessnas took the runway, and at 0705 the flag fell and flight leader Jack Cronin's yellow and white 140 lifted off into the haze. Every three seconds another 140 surged ahead, and slowly but surely 161 airplanes rose into a undulating line that stretched for 30 miles. The Chicago Air Route Traffic Control Center monitored the flight, and Oshkosh prepared to close its runways to all other traffic for the half-hour needed for the caravan to land. About two hours after takeoff the world's largest flight of Cessnas set a record for formation flights into Oshkosh when it touched down at the world's largest aviation bash.

—Thomas G. Foxworth

Automobile drivers using a Head-Up Display (HUD) need not divert their eyes from the road to view information ordinarily shown in the instrument panel. The HUD focuses key driving data, including vehicle speed and turn signal indicators, through the windshield, so the data appears to be suspended over the front bumper. The system design is derived from HUDs used in today's advanced fighter aircraft. Developed by Hughes Aircraft Company, Delco Electronics, and General Motors, the automotive HUD uses a collimating optical system, with an electronically driven, high-performance display device. The world's first production cars equipped with a HUD will be the 1988 Cutlass Supreme Indianapolis 500 Pace Car and limited edition replica cars.

Hughes quality inspectors are using a voice input system on the production line to significantly reduce time and cost during the inspection of advanced radar modules. A major advance in speech-recognition technology, the Hughes-built system combines computers and artificial intelligence techniques with software programming designed by Hughes. The computers, with a vocabulary of up to 1,000 words, give verbal instructions, repeat the inspector's words for verification using a built-in voice synthesis feature, and then record the information. Introduced on the APG-65 radar production line, additional voice input systems are being installed on other radar production lines.

A new printed wiring board (PWB) significantly reduces the manufacturing cost of large backplanes, or motherboards, while improving producibility, performance, and reliability of the computers they help operate. Developed by Hughes for military computer applications, the 18-layer PWB contains 7,500 fewer wires than the one it is designed to replace, and may be the most complex such board ever manufactured. The multilayer design of the new board minimizes the number of machine-wrapped wires, requiring only 2,500 such wires, compared to 10,000 on present PWBs, thus greatly simplifying assembly and inspection.

NASA's Magellan Mission will carry only one scientific instrument during its detailed mapping exploration of the planet Venus. The Hughes-built synthetic aperture radar (SAR) will gather data in greater detail than any of the previous 20 U.S. and Soviet Venus probes. It will transmit images 30 times sharper than those gathered by the Hughes-built Pioneer Venus, which provided the first extensive scientific study of the planet. In a fixed polar orbit, Magellan will take 243 days to map nearly all of the planetary surface, taking pictures for 37 minutes during each of its three-hour orbits. The remaining time in orbit will be spent transmitting the data back to scientists on Earth.

Support Systems in Southern California designs, develops, and manufactures some of the most sophisticated training simulators and a wide array of automatic and manual test systems. In addition, field engineering and technical support of a wide range of electronic systems keep Hughes' systems operating at top efficiency worldwide. Opportunities are available for a variety of engineers qualified by degree or work experience. They include systems, radar, MATE control and support software engineers, logic designers and image processors. Please send your resume to Lowell Anderson, Professional Employment, Dept. S4, Hughes Aircraft Company, P.O. Box 9399, Long Beach, CA 90801-0463. Equal opportunity employer. U.S. citizenship required.

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Storm Window

One of the first things a pilot learns is to give thunderstorms a wide berth. Wind, rain, hail, and lightning can wreak havoc on even the strongest aircraft. So when a storm is brewing, why does Bruce Miller hop into a 20-year-old sailplane and head straight for it?

It's all in the name of weather research. Since the mid-1960s the National Center for Atmospheric Research has drafted pilots to fly into Colorado and New Mexico thunderstorms to measure their water content, temperature, and electrical fields.

Miller says his Schweizer SGS 2-32 sailplane is perfect for the job. A building cumulonimbus updraft is often less than five miles across, and Miller can keep his sailplane in a tight circle to stay within the heart of the ascending column. In addition, the lack of exhaust fumes makes for more reliable particle sampling, and updraft speeds are more accurately calculated using a motorless aircraft.

Miller doesn't challenge full-blown storms, the ones that top out at 50,000 feet with a distinctive anvil-shaped cloud. "That would be semi-suicidal," he says. Besides, NCAR scientists want to know more about early stages of thunderstorm development. So Miller hunts for clouds in the towering-cumulus stage, fleecy and calm without, wet and turbulent within.

On a typical mission Miller and sailplane are towed for one or two hours late on a summer morning in search of the ideal cumulus. "I pretty much decide which one to go in," Miller says. "I'm up there watching it evolve and I know what the lift situation is." He then dons an oxygen mask, plunges into the cloud, locates the updraft, and ascends with it in a constant turn. With a 2,000-feet-per-minute rate of climb, he can rise from a relatively mild cloud base to heavy icing regions at 26,000 feet in minutes.

In a strong enough updraft Miller can soar well above the usual sailplane altitudes of 3,000 to 20,000 feet. On his final flight for the summer of 1987's research Miller had cracked 35,000 feet when the sparks began to fly. "All of a sudden the electrical activity increased tremendously," he says. "I started seeing flickers, then an actual lightning bolt crossed in front of the canopy. It sounded like someone had shot a gun next to the glider." He dashed out of the storm at 38,800 feet with a wealth of data.

Jim Dye, a NCAR scientist in Boulder, hopes Miller's findings will enable him to study the phenomenon of intracloud lightning. Scientists believe collisions between ice particles help create a

NCAR

negative-charge region near the base of the cloud and a positive region at its top. The result is a highly charged cloud with lightning as the discharge path. Future flights will carry a probe to measure the charge of particles as they pass through a laser beam and an electrified ring.

When not exploring thunderstorms Miller operates a sailplane rental business in Boulder. The city's agreeable climate and spectacular views make it a soaring haven and give Miller a chance to do some flying in less electrifying conditions.

—Robert Henson

Moved by the Spirit

No one took a head count at Long Island's Roosevelt Field on May 20, 1927, the day the *Spirit of St. Louis* staggered into the air and headed for Paris. But 80 eyewitnesses gathered last spring when the Friends for Long Island's Heritage held a reunion of the crowd that had held its breath that rainy Friday morning when Lindbergh and the *Spirit* cleared the telephone wires at the end of the runway.

Reports of the clearance between airplane and wires varied at the time, and good-natured disputes continued when the Eyewitness Club met on June 9 at Falaise, the former Harry Guggenheim mansion in Sands Point, Long Island. The members were there to kick off a fundraising drive and contribute to an oral history project sponsored by the Heritage group. Edward Robedee, who was 16 in 1927 and lived in Merrick, remembered the distance between airplane and wires as "not more than 20 feet." John Amrhein thought the margin was smaller, a little more than the spread of his arms. "I would say about 10 feet."

Margaret Sparrow's eyes brightened when she recalled meeting the handsome 25-year-old pilot. She had seen him several times before the flight while working at Barley's Pharmacy in Westbury. She was Margaret Small then, and also 25. "I wasn't

bad looking," Sparrow said. "I got a pinch like this from him." And what did she think of Lindbergh? "A natural big kid. I should have set my tracks for him. I was very famous for my sodas and things in those days."

Shirley Cozzetti went to the airport with her mother and father. Her clearest memory is not of the man or the airplane. "I remember a little kitten being there. He wanted to put it on the plane and take it across with him to Paris. All I remember is it wasn't allowed." Her mother made sure she got a good view of the takeoff. "Anything interesting, my mother was there," said Cozzetti. "If I know my mother, she pushed her way to the front."

"It was subdued, drizzly, dark," said Rita Moore, who went to the airfield on Sundays for entertainment. "We were always there. We had the radio on and kept listening for

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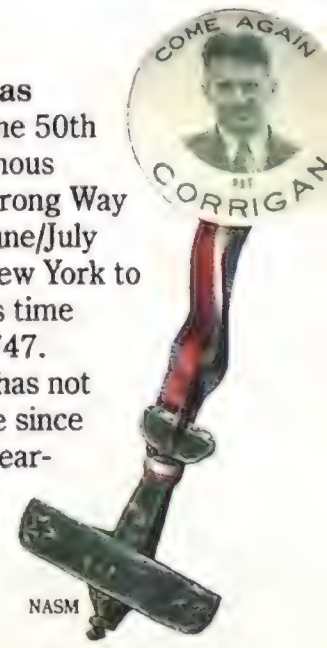
news that this would be the day. As he taxied down the field the whole crowd breathed in."

In Model Ts or on foot, scores of people had crossed paths that day in 1927, skipping school or work to catch a glimpse of history in the making. Sixty-one years later, on a June afternoon, they crossed paths again, this time to remember history and their part in it and to say, "We were there."

—Carl H. Lavin

Update



The reclusive Douglas Corrigan celebrated the 50th anniversary of his infamous transatlantic flight ("Wrong Way Corrigan Revisited," June/July 1988) by flying from New York to Dublin on July 17—this time aboard an Aer Lingus 747. Corrigan, who says he has not been aboard an airplane since 1965, made a brief appearance at California's Long Beach Municipal Airport a week earlier to meet with fans.

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India's second attempt to launch its new five-stage rocket on July 13 failed when the first stage would not fully ignite ("The Chariot of Indra," April/May 1988). Three minutes after liftoff from the Sriharikota Island pad, the Augmented Satellite Launch Vehicle, which was to place an Earth observation satellite in low orbit, went out of control and plunged into the Bay of Bengal.

India's Insat 1C telecommunications, remote sensing, and meteorological satellite was launched by an Ariane 3 from Arianespace's French Guiana facility on July 21.

TIGHAR

New highs and lows in the four-year attempt to recover the White Bird ("The Search for *L'Oiseau Blanc*," February/March 1987): two metal pieces, discovered in a Maine swamp during last fall's Expedition XIII, may be French aircraft seat belt buckles. Curators at the Musée de l'Air et de l'Espace in France are trying to make a firm identification.

Recent publicity about the search has elicited three reports of a news story aired in the early 1970s about hunters removing an old aircraft engine from the Maine wilderness. "If the wreckage of *L'Oiseau Blanc* is stashed in the back of somebody's barn," says Rick Gillespie, founder of the International Group for Historic Aircraft Recovery, "it's just as lost to us as if it were still buried in the woods."

The increase in space junk ("Eyes on the Sky," April/May 1987) translates to a one-in-30 chance of the shuttle suffering damage from orbiting debris, according to NASA. More than 7,000 fragments as small as four inches are now being tracked. Studies at the Massachusetts Institute of Technology indicate that there are some 50,000 smaller and untrackable objects. NASA is researching better satellite shielding and plans to increase tracking capabilities.

OSCAR 13, the latest amateur radio satellite, was launched June 15 from French Guiana on the first Ariane 4 ("Homemade Satellites," December 1986/January 1987). The 200-pound satellite, which is carrying five transponders, became available to 10,000 users last July 22.

—Patricia Trenner

Anniversaries . . .

1860
October 13 J.W. Black takes the first well-defined photograph of the United States from a balloon. Using a collodion plate, Black took a picture of downtown Boston from 1,200 feet in the tethered balloon *Queen of the Air.* Oliver Wendell Holmes later described the photograph in *The Atlantic Monthly*: "Boston, as the eagle and the wild goose see it, is a very different object from the same place as the solid citizen looks up at its eaves and chimneys."

International Museum of Photography/Rochester, NY

J.W. Black's bird's-eye view of downtown Boston was a photographic first.

1900
October 14 From his camp near Kitty Hawk, North Carolina, Orville Wright writes a letter to his sister Katharine in Dayton, Ohio: "A mockingbird lives in a tree that overhangs our tent, and sings to us the whole day long. We often think of him in the night, when the wind is shaking the top and sides of the tent till they sound like thunder, and wonder how he is faring.

"The sunsets here are the prettiest I have ever seen. The clouds light up in all colors. The moon rises . . . and lights up this pile of sand almost like day."

1924
October 29 To test a method of improving aerial visibility, two Army airplanes break up clouds over Washington, D.C.'s Bolling Field by injecting them with electrified sand particles. Slung beneath the aircraft fuselages were tanks filled with fine-grain silica and charging nozzles that dispensed both positive- and negative-charged sand. When rain fell after the clouds dispersed, L. Francis Warren, who devised the process, proclaimed, "Commercial rainmaking now lies within the grasp of man."

Pan Am's Clippers *were a common sight above the San Francisco Bay in the 1930s.*

1935
November 22 Pan American Airways launches the first trans-Pacific airmail service with the *China Clipper*'s six-day journey from Alameda, California, to the Philippines. Passenger service began a year later, after Pan Am built hotels on four stopover islands: Hawaii, Midway, Wake, and Guam. For $799 one way, passengers enjoyed sleeping berths, private sitting rooms, and five-course meals served in the dining room. After landing, travelers were greeted with leis and escorted to their hotel. The adventure and glamour of the *Clipper* flights sparked Depression-era imaginations—the name *China Clipper* turned up on restaurants and as the title of a Warner Brothers movie featuring Humphrey Bogart. Everyone loved the flying boats except Japan, which protested U.S. Navy assistance of Pan Am's expansion into the Pacific.

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Jack Northrop's dream took flight when the YB-49 winged its way over California.

1947
October 21 The eight-engine Northrop YB-49 Flying Wing Bomber makes its first flight, taking off from Hawthorne, California. The Air Force saw the unique jet as a potential long-range strategic bomber: two YB-49s had displayed outstanding range, speed, and load carrying ability during flight testing. Despite the crash of the No. 2 prototype after its outboard wing sections broke off, the Air Force ordered the YB-49 into production, but the contract was later canceled due to budget reductions and the Air Force's desire to quickly assemble a combat-ready bomber force. The flying wing has recently resurfaced in Northrop's new B-2 stealth bomber.

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Powered by twin ramjets, the XH-20 needed no transmission or tail rotor.

November 16
McDonnell Aircraft publicizes the successful flight testing of its ramjet helicopter, the XH-20, also called Little Henry. Developed for the Air Force, the XH-20 was powered by 10-pound ramjet engines on the tips of its twin-blade rotor. Although simple construction and projected low maintenance made the XH-20 the ideal aircraft for frequent short-range observation and courier flights, its noisy, fuel-thirsty ramjets kept Little Henry from reaching production.

1962
October 14
Two Air Force pilots flying U-2s on reconnaissance missions over San Cristobal, Cuba, photograph missile erectors and launchers, the first hard evidence that the Soviet Union is sending nuclear offensive weapons to Cuba. Three days later the United States had its first images of medium- and intermediate-range ballistic missiles on Cuban soil. On October 22, President John F. Kennedy announced the deployment of an air and naval blockade to stem the flow of missiles into Cuba.

UPI/Bettmann Newsphotos

Barney Hill reported seeing a bright object with two rows of windows.

1975
October 20 NBC premieres *The UFO Incident,* starring James Earl Jones and Estelle Parsons. The film depicted the story of Barney and Betty Hill, who reported that on the night of September 19, 1961, while driving through New Hampshire's White Mountains, they sighted a bright disk-shaped object that remained in view for approximately 30 miles. When they got home, the Hills realized that they could not account for two hours of their trip. During hypnosis the couple described being taken aboard the UFO for physical examinations, but a psychiatrist they consulted believed that their stories derived from Betty's abduction nightmares and Barney's sensitivity to racial prejudice, rather than an actual UFO encounter.

1980
November 12 Voyager 1 comes within 77,000 miles of Saturn during its observations of the solar system's second largest planet. "We've learned more about Saturn in the past week than in the entire span of recorded history," said Bradford A. Smith, head of the Voyager imaging team. Imagery indicated winds of 900 mph at the planet's equator and confirmed the existence of three satellites. Voyager 1 is now 3.2 billion miles away from Earth, its instruments returning information on the solar wind.

. . . and Events

August 29–October 5
World Administrative Radio Conference. Hosted by the International Telecommunication Union. Delegates from 163 countries will discuss the allocation of radio frequencies, a finite natural resource used by geostationary communication satellites. Third-world countries want a share of the dwindling unused frequencies even though it may be decades before they can launch satellites that will utilize them. At Geneva, Switzerland. Call ITU at 41 22 995111.

October 1 & 2
Wings Over Houston Airshow. Blue Angels and more than 100 World War II aircraft. At Ellington Field, Houston, TX, (713) 531-9461.

October 15
Washington County Regional Airport Open House. Hot-air balloons, ultralights, and helicopter rides. At Hagerstown, MD, (301) 797-7467.

October 15 & 16
El Paso International Amigo Airsho. Thunderbirds, Red Baron Squadron, Golden Knights, and Zar, the Aerobatic Alien. At Biggs Army Airfield, El Paso, TX, (915) 545-2864.

October 27–30
"War of the Worlds": The 50th Anniversary. The town of West Windsor, New Jersey, celebrates Orson Welles' radio broadcast of an imaginary Martian invasion of Grover's Mill, a nearby village. Bike race, art show, Martian parade, and a panel discussion entitled "Could It Happen Again?" P.O. Box 716, Princeton Junction, NJ 08550.

October 29
Airliner Expo. Airline memorabilia and trivia contest. At Sheraton Atlanta Airport Hotel, Atlanta, GA, (404) 292-6969.

October 29 & 30
Miami Air Show. Sponsored by the Association of Naval Aviation. Blue Angels, Concorde, and Harrier. At Opa Locka Airport, Miami, FL, (305) 685-7025.

Organizations wishing to have events published in Calendar should submit them four months in advance to Calendar, Air & Space/Smithsonian, *National Air and Space Museum, Washington, DC 20560. Events will be listed as space allows.*

—Diane Tedeschi

The Kingfisher's New Floats

The call from Alaska came on a Sunday evening in late spring, 1979. "Bob, we have just been ravaged up here," the voice said. "Would you believe that some junk collector came in here and took one of the crashed Kingfishers out of Afognak Island, carted it off by boat, and was last seen heading for Seattle?"

Robert Mikesh, the National Air and Space Museum's senior aeronautics curator, could believe it. In fact, he thought he knew just who the perpetrator was.

The Museum had recently started up an effort to restore its own Vought-Sikorsky OS2U Kingfisher, a scout-and-rescue airplane from World War II. But when the Kingfisher entered the Museum's collection it was on wheels instead of the more characteristic large central float. Mikesh contacted the original float maker in Long Island, the Edo Corporation, to see if it could manufacture a new one. The company couldn't—the tooling had vanished—but Edo agreed to help in any other way it could.

After he received the Sunday night call, Mikesh called a contact of his at Edo. Sure enough, it turned out that the well-meaning float company was behind the disappearance of the Kingfisher from Afognak Island. "As a matter of fact," his contact told him, "we contracted with a man who recovers junk in Alaska to recover one in the hopes of us rebuilding this float for you, Bob."

Meanwhile, other calls started to come in. The Navy called, Mikesh says, "claiming that one of their airplanes had been stolen, even though it had been crashed and written off the books since 1943." And the Alaskan Historical Aircraft Society, a member of which first told Mikesh of the missing airplane, expressed its displeasure: the historians felt that the people of Alaska had a legal right to any relics found in their state.

Mikesh soon satisfied the concerned parties that the Museum was a worthy recipient of the wrecked Kingfisher. But the unexpectedly eventful search for a float was destined to go into extra innings. When the wreck was trucked to Edo, the company found the float to be unrestorable.

Another float turned up beneath 15 cars in a junkyard on Alaska's Kodiak Island.

Finding them took four years, but the floats are clearly fit for a Kingfisher.

Mark Avino/NASM

After the spring thaw, the U.S. Coast Guard helped remove and ship the parts. They, too, proved unrestorable, although the wreck did yield the necessary pylons, wires, float caps, and other accessories useful in completing the restoration.

In early 1982 Edo located another candidate: a main float in good condition owned by a St. Petersburg, Florida man. But he had plans to build a Kingfisher to put on top of it and didn't want to give it up.

Meanwhile, an ad the Museum had placed in *Trade-a-Plane,* the three-times-a-month forum for people looking to buy, sell, or trade aircraft and aircraft parts (see "Cake, Candles, Ice Cream, and Classifieds," October/November 1987), started to pay off. Yet another float surfaced in Alaska, the property of a fisherman who wanted $10,000 for it. "Well, we don't buy things," Mikesh says, "but it was much more inexpensive to buy that than to try to make one." Mikesh haggled him down to $6,000, and Michael Collins, astronaut, former Museum director, and at the time an executive with LTV, which had merged with Vought, came to the rescue by arranging for LTV to buy the float for the Museum.

But the float in St. Petersburg was not only a lot closer, it was also in better condition. Mikesh decided to make one more try and sent the owner a letter offering the $6,000 LTV had agreed to put up. When the owner's father heard about the offer, he urged his son to accept it, in essence telling him to get that junk out of the yard immediately. The son complied.

When the main float arrived in late 1982 it was accompanied by two wingtip floats, but they were in poor condition. This presented little problem for the now-seasoned float hunter. The *Trade-a-Plane* ad had also resulted in a contact with a helicopter dealer in South Daytona Beach, Florida, who had a set of wingtip floats, although his kids had welded them together to serve as floats for a boat. "But he was willing to let them go if I would cough up a surplus government turbine engine from a helicopter," Mikesh says. With the Navy's contribution of an engine, the deal was done and the airplane's restoration could finally begin in earnest. It was completed earlier this year, some 10 years after the search for the floats began.

The Kingfisher's role in active service to the Navy was completed more quickly. Created in the late 1930s to be the eyes of the Naval fleet, the first production Kingfisher flew in 1940. It rode aboard the decks of battleships and cruisers, where it was launched on scouting missions by a catapult using compressed air, a practice first successfully used in 1912. The seaplane, which could also be fitted with wheels to serve as a landplane, was durably constructed to withstand the rigors of repeated catapult launchings. But by Pearl Harbor the Kingfisher had become largely obsolete, and by 1944 it was no longer in production. Today helicopters aboard ship carry out much of the work once assigned to the OS2U.

Six restored Kingfishers are known to exist today, and other than the Museum's, only two of these are displayed with original floats. The Museum's Kingfisher is now on display at the back of Building 20 at the Museum's Paul E. Garber Preservation, Restoration and Storage Facility, where its rare floats and new cloak of paint—the colors it wore while in service during World War II—clearly place it in an earlier era.

The airplane itself offered up other evidence of its antiquity. "I found a little folded-up piece of square paper and very delicately unfolded it and cleaned it off with acetone," says Bill Reese, a restoration expert at the Garber Facility. "It was a five-cent Hershey bar wrapper."

—Karen Jensen

A joint ESA-NASA project, Ulysses will explore the sun and heliosphere. ESA

ESA Does It

Seeking to publicize their scientific satellites, members of the European Space Agency brought some scale models to an International Astronomical Union General Assembly in Baltimore this summer. But that was preaching to the converted. When the Museum's director, Martin Harwit, stated that he intended to broaden the Museum's scope to give more credit to international aerospace achievements, ESA saw a golden opportunity for publicity. The agency asked Harwit if he'd like to host its display for five months after the conference, and Harwit said yes.

Full-scale models of ESA's four most famous scientific satellites form the exhibit's heart and will be on display in the Museum's west end until mid-January 1989. Giotto, the spacecraft that flew closest to Comet Halley in the spring of 1986, is probably the most familiar to U.S. viewers. ESA scientists hope that the probe will rendezvous with another comet in 1992, but its close encounter with Halley's dust may have shortened its lifespan. EXOSAT accomplished its mission between 1983 and 1986, when it studied the X-ray spectra of supernovae, neutron stars, and other celestial objects. When Hipparcos is launched next year, it will make precise measurements of the distances between stars. And the ESA-NASA joint project Ulysses, represented here by an engineering test model that missed the Baltimore exhibit debut, is currently scheduled for a shuttle launch in the early 1990s. With a gravity assist at Jupiter, Ulysses will fly out of the solar system's plane to study the sun's poles.

The satellite models in the display are supplemented by a model of Comet Halley's nucleus as it appeared to Giotto, a video based on the comet encounter, and detailed descriptions of several other scientific missions ESA plans for the 1990s. Future European spacecraft will study the interaction of Earth's magnetic plasma with the solar wind, the sun's heliosphere, and infrared emissions, among other things.

"I wanted to be able, at least for a short while, to show that there was a lot of interesting work going on in Europe," says Harwit of the exhibit. "We often hear about the Soviet Union as our main competitor in space, but I think that in the scientific area the Europeans may even be ahead of the Soviet Union."

Harwit's new policy should help visitors decide for themselves which nation leads in

the space race: negotiations are currently under way to bring a Soviet Vega craft here on a five-year loan.

—Katie Janssen

Fun Fur

What do *The Spirit of St. Louis* and the Mercury *Friendship 7* have in common with a few small, foam-stuffed balls of fake fur? All are part of the Museum's collection. The furry spheres, easily recognized by the fans of the TV series "Star Trek," played the title creatures in one of the series' most popular episodes, "The Trouble With Tribbles."

"The Trouble With Tribbles" was notable for its humorous dialogue, but what made it so memorable were the tribbles themselves. They cooed, purred, and trilled—especially when picked up and cuddled—which quickly endeared them to the *Enterprise* crew. The trouble with the beasts proved to be their fecundity. With each tribble able to produce an average litter of 10 every 12 hours, the starship was soon overrun with them.

The Museum acquired what may be its cutest artifacts when "Star Trek" script editor Dorothy Fontana told the episode's author, David Gerrold, that the Museum was interested in acquiring memorabilia from the show. Gerrold decided he could part with some of his tribbles, and in February 1973 a small family of them arrived at the Smithsonian from Hollywood.

With bureaucratic formality, the tribbles, like any other acquisition, were cataloged. A portion of the registration form reads: "Small white Tribble. 3x3x2 in. Slightly soiled. Large brown Tribble. 4x4x3 in. Good condition."

Of the 500 tribbles constructed for the show, three now lead a quiet existence on display at the Museum's Paul E. Garber Facility in Maryland. In a glass case at the back of Building 24, a large brown tribble and a small white one snuggle on a shelf, while a tiny brown tribble appears to be crawling toward a supply of space food. The other two tribbles are in storage.

Consisting of no more than an outer shell of synthetic fur and a stuffing of foam rubber, most tribbles were inanimate. A few, however, had to show signs of life by breathing and throbbing. To simulate breathing, a surgical balloon was inserted into one of the fur shells and inflated with a squeeze bulb and plastic tubing. Six crawling tribbles were actually battery-operated, decapitated toy dogs covered with a tribble skin opened at the bottom for the dogs' legs.

Although new tribbles are sold at most Star Trek conventions, the original 500 have become collectors' items. Two hundred were donated to a fundraising auction after the show was filmed; cast, crew, and a few lucky fans divvied up the rest. Contrary to their fictional nature, however, these tribbles—including the Museum's stable of five—show no signs of increasing their numbers.

—Diane Tedeschi

Museum Calendar

Except where noted, no tickets or reservations are required. Call Smithsonian Information at (202) 357-2700 for details.

New Exhibit "Focus on Flight." Winners and other selected entries of the 1988 Focus on Flight amateur photography contest will be on display in the Pioneers of Flight Gallery starting October 31.

"Cold War" Aviation Film Series Feature-length films will be shown free in the Langley Theater one Thursday a month at 7:30 p.m. Oct. 13: *The Big Lift* (1950); Nov. 17: *Toward the Unknown* (1956).

October 1 Monthly Sky Lecture: "War of the Worlds." Celebrating the 50th anniversary of the radio broadcast that shocked the nation. Amateur astronomer Stanley Cawelti, Einstein Planetarium, 9:30 a.m.

October 19 Smithsonian Resident Associate Program lecture: "Supernova Illuminates Cosmic Mysteries." New discoveries from the spectacular supernova sighted last year. Robert P. Kirshner, Harvard University. Carmichael Auditorium, American History Museum, 8:00 p.m. Cost: $7 for members, $9 for non-members.

October 20 General Electric Aviation Lecture: "Yeager on Yeager." Brig. Gen. Charles E. "Chuck" Yeager. Tickets will be distributed at the Langley Theater box office beginning at 5 p.m. on a first-come, first-served basis. Theater doors open at 6:30 p.m. Langley Theater, 7:30 p.m.

November 3 General Electric Aviation Lecture: "Adventures of an Alaskan Bush Pilot." Aviation writer and photographer Don "Bucky" Dawson on the career of pilot Harold Gillam. Langley Theater, 7:30 p.m.

November 5 Monthly Sky Lecture: "The Atomic Clock." Mihran Miranian, U.S. Naval Observatory, Einstein Planetarium, 9:30 a.m.

Vivaldi, The Four Seasons The English Concert/Pinnock. Archiv *DIGITAL* 115356

Horowitz In Moscow Scarlatti, Mozart, Rachmaninov, Liszt, Chopin, Scriabin, others. DG *DIGITAL* 125264

Perlman: French Violin Showpieces Havanaise, Carmen Fantasy, Tzigane, more. DG *DIGITAL* 115457

Tchaikovsky, 1812 Overture; Romeo & Juliet; Nutcracker Suite Chicago Symphony/Solti. London *DIGITAL* 125179

By Request...The Best Of John Williams & The Boston Pops Olympic Fanfare, Star Wars, more. Philips *DIGITAL* 125360

Brahms, Cello Sonatas Yo-Yo Ma, cello; Emanuel Ax, piano. Grammy Award Winner! RCA *DIGITAL* 154044

Galway & Yamashita: Italian Serenade Flute & guitar works by Paganini, Cimarosa, Giuliani, others. RCA *DIGITAL* 173824

Gregorian Chant Schola of the Hofburgkapelle, Vienna. Hauntingly serene. Philips *DIGITAL* 115434

Slatkin Conducts Russian Showpieces Pictures At An Exhibition, more. RCA *DIGITAL* 154358

Debussy, La Mer; Nocturnes Boston Symphony Orchestra/Davis. Philips *DIGITAL* 115068

Beethoven, Symphonies Nos. 4 & 5 Academy of Ancient Music/Hogwood. L'Oiseau-Lyre *DIGITAL* 115009

André Previn: Gershwin Rhapsody In Blue, Concerto, An American In Paris. Philips *DIGITAL* 115437

Mozart, The Piano Quartets Beaux Arts Trio; Bruno Giuranna, viola. "Absolutely indispensable."—Stereo Review Philips *DIGITAL* 115271

Teresa Stratas Sings Kurt Weill Surabaya-Johnny, Foolish Heart, 13 more. Nonesuch 124748

Tchaikovsky, Symphony No. 4 Chicago Symphony Orchestra/ Solti. London *DIGITAL* 125038

Dvořák, Symphony No. 9 (New World) Chicago Symphony/Solti. London *DIGITAL* 115168

Mendelssohn, A Midsummer Night's Dream Neville Marriner, cond. Philips *DIGITAL* 115546

Ravel, Daphnis et Chloé (Complete) Montreal Symphony/Dutoit. London *DIGITAL* 115520

Mozart, Requiem Leipzig Radio Choir; Dresden State Orchestra/ Schreier. Philips *DIGITAL* 115039

Pavarotti: Volare Title song, Serenata, 14 more. With Henry Mancini. London *DIGITAL* 125102

Handel, Water Music Eng. Concert/ Pinnock. Archiv *DIGITAL* 115306

Rossini, Overtures Barber Of Seville, Tancredi, 6 more. Orpheus Chamber Orch. DG *DIGITAL* 115527

Horowitz Plays Mozart Concerto No. 23 & Sonata No. 13. Giulini conducts. DG *DIGITAL* 115436

Eine kleine Nachtmusik Plus Pachelbel Canon, more. Marriner conducts. Philips *DIGITAL* 115530

The Canadian Brass: High, Bright, Light & Clear Baroque gems. RCA *DIGITAL* 144529

Bach, Goldberg Variations Trevor Pinnock, harpsichord. "Definitive."—Stereo Review Archiv 105318

Rachmaninov, Piano Concertos Nos. 2 & 4 Vladimir Ashkenazy. London *DIGITAL* 125074

Holst, The Planets Montreal Sym./ Dutoit. London *DIGITAL* 115448

Handel, Messiah (Highlights) Musica Sacra/Westenburg. Hallelujah Chorus, more. RCA *DIGITAL* 153586

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No Joystick in the White House?

George Bush may think that he is running against Michael Dukakis, but the truth is he's bucking a system that is nearly cosmic in its implacability. He is offering the country a background that has rarely been welcome in the White House: he is a pilot.

Pilots can't be presidents. No military pilot has ever held the office. The stuff that saw George Bush through the South Pacific war in an Avenger torpedo bomber appears to be the wrong stuff for steering the country.

If you don't believe it's tough for a pilot to make it to the Oval Office, just think of the sinuous path that private pilot Gerald Ford had to take. Wherever it is written that pilots can't be presidents, there is a footnote that says "unless he is a private pilot who takes over for a vice president who resigns and, in the same term, takes over for a president who resigns."

The office is not unattainable; election to it is. A quick analysis of elections held in this century proves that pilothood is a two-faced jinx. It sometimes gets you the nomination, but it keeps you from getting the job. It worked this way for Barry Goldwater in 1964 and George McGovern in 1972. It must have been critical in making Bush the Republican nominee. Certainly the survival instinct necessary for wrangling, live, on national television with a bulldog reporter is well developed in a man whose aircraft lost oil pressure just as it hurtled off the deck of a carrier. But the luck stops at snagging the nomination. The Fates, knowing Bush for a pilot—one is a pilot as one is a bicycle rider, eternally, even if one stops after a few years—shake their heads and murmur, "No way, Jorge."

One wonders if these men, as young fliers, sensed that if they were called, they almost certainly would not be chosen. Did Bush, floating in his one-man raft after ditching in the Pacific, hear distant drums along Pennsylvania Avenue and divine how futile pilothood would make such fantasies? Did thoughts of being president buoy Barry Goldwater during those long, long ferry flights across the waters, or 21-year-old George McGovern, pushing his B-24 up the Apennines from North Africa? More to the point, did they ever have an inkling that the very engines lulling them into fantasy marked them forever as men who would not be kings?

John Glenn, the man who essentially defined what is called "the right stuff," further supports the law that pilots may command but never rule. I have heard him described, by people who worked hard for his futile run for the Democratic nomination, as "bo*r-rr*ing." Apparently,

Kim Barnes/Stansbury, Ronsaville, Wood Inc.

any man whose heart rate doesn't accelerate madly in the nose cone of a low-reliability rocket is perceived as dull. Some of us would use the word "calm." The voters used the word "no."

Maybe it isn't fate at all but something about piloting itself that forever undermines its practitioners. Maybe pilotness prevents election because of the incurably untroubled note it produces in the voice. The screaming youngsters in the film *Top Gun* to the contrary, pilots are not a shrill race. The delivery from a pilot's podium has the quality you hear on the air traffic control channel.

Early in the campaign, Bill Horrigan, a United DC-10 first officer from Woodbury, Connecticut, gathered support for this theory—the only thing for which he did gather support. Horrigan didn't win a single delegate in the New Hampshire primary. Perhaps this is because United Air Lines, Horrigan's employer, lets passengers listen in on the air traffic control frequency, even when things are tense. Thousands, perhaps millions, of voters had heard Horrigan being a pilot. He didn't have a chance.

Voters seem to wish for presidents who are prophets, who speak plangently of vast possibility, rather than pilots who can summarize with a clipped "Roger; over." When Barry Goldwater suggested matter-of-factly that it was time to bomb a Stone Age society into the Pleistocene, it was his nonchalance that made him seem a monster. On the other hand, the booming of his opponent, a man with the noisy confidence of a used-horse trader, sounded to the electorate like the voice of leadership.

The nomination of a non-pilot is the strongest evidence offered thus far that the Democrats are serious about winning in 1988. In fact, Democratic victory was assured until Michael Dukakis, in what historians may see as a fatal lunge toward fairness, added a pilot to his ticket. If the cosmic law prevails, Senator Lloyd Bentsen, who learned his particular brand of pilot politics in a B-24, is more of an advantage to Bush than to Dukakis.

Of course there is the exception that proves the rule. One man beat the curse.

Back in July 1939, a 49-year-old Army lieutenant colonel stationed in the Philippines got his certificate of competency in a Stearman PT-1. Between July 1936 and November 1939, he logged some 350 hours. Despite the fact that his pilot's license was a matter of public record and not suppressed by his campaign publicists, he won the presidency—twice. Perhaps George Bush will become the second elected pilot president, swept into office on a tide of nostalgia for those calm, direct, and rather understated days when Dwight Eisenhower flew the country. The Democrats have given him a chance. Now the country will have to choose a pilot; the only decision is whether he will sit in the left seat or the right.

—Carl A. Posey

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Shadow Boxing

The NASA inspector barked and we jumped, scurrying out of the airplane and onto the tarmac. A few feet away jet fuel was streaming from the left wing, collecting in a growing puddle and warming quickly in the Hawaiian sunlight.

On the faces of MIT astronomers James Elliot and Edward Dunham, confusion quickly gave way to concern. We had been just minutes from takeoff, but now our departure was certain to be delayed. Seven hours and nearly 3,000 miles away, a remarkable phenomenon awaited us—the shadow of Pluto as the planet passed in front of a star. Never before had this strange little world given astronomers the chance to answer so many questions, such as whether it has an atmosphere. But making that rendezvous, a mission years in the planning, now all came down to how quickly the airplane's hemorrhaging could be stanched.

Someone radioed for a fire crew, but the fuel stopped leaking long before the truck arrived. The problem turned out to be minor: the wing tanks had been topped off with cold fuel, and in the heat it had expanded and overflowed. Only an inconsequential fraction of the 142,000-pound fill-up had been lost. "The new astronomy," Elliot sighed.

I climbed back aboard with the others and readied for a quick departure. Compensating for lost time would prove difficult. Pilot Bill Brockett eased the airplane off the runway about 12 minutes behind schedule and headed south. "If the winds aren't too far off we ought to make that up," he told us.

A sense of calm returned as the astronomers occupied themselves with preparations. This was the only airplane in the world able to accomplish what they wanted to do that night. The four-engine C-141A StarLifter had been converted by NASA during the 1970s into the Kuiper Airborne Observatory (KAO), known to its crew as the Queen. Just forward of the wings sat an observatory-class telescope with a mirror 36 inches across. Sealed off from the pressurized cabin around it by a thick bulkhead and isolated from the airplane's swaying and vibrations by air bearings and a three-axis, gyro-stabilized mount, it would soon peer out through a square hole in the fuselage.

The KAO flies 75 to 80 missions each year from its home at NASA's Ames Research Center, 30 miles south of San Francisco. Cruising at 41,000 feet or more, the airplane lifts astronomers above most of Earth's atmosphere and virtually all the water vapor that blocks infrared observations at ground level. The KAO can record a solar eclipse on one flight and peer into the Milky Way's dusty heart the next.

I made my way toward the back, past the massive rack of electronics that controlled the telescope and recorded its observations. Jim McClenahan, the KAO's facility manager, stared up at the simple, outdated-looking readouts and kept a close eye on the headwinds. Noisy and chilly, the no-frills cabin is several steps down from business class. Dozens of hydraulic lines and electronic cables snake along its bare walls and oxygen masks dangle from the ceiling. Expedition manager Carl Gillespie had stuffed this flight with backup personnel, as was evident from the tangle of headset cords on the floor.

Elliot and Dunham's Pluto-watching plan required an expedition to the Southern Hemisphere, similar to those undertaken in centuries past by astronomers hoping to glimpse rare astronomical phenomena. Stopovers in Hawaii and American Samoa would be necessary; an entire ground crew had to come along too. "We don't want to fail on a mission away from Ames," McClenahan explained, "and we tend to cover ourselves."

It was big-time science, the kind that makes for fundamental discoveries, seminal journal articles, and plenty of media attention. The objective was to witness what astronomers call an occultation. Just as the moon periodically eclipses the sun, the planets and asteroids occasionally cross in front of a star and briefly keep its light from reaching Earth. In 1977, for example, Elliot and Dunham used the KAO to watch Uranus occult a star. On that flight, they were astonished to discover that the planet is surrounded by a family of delicate rings.

In the six decades since its discovery, Pluto had somehow eluded these cosmic cover-ups, though there had been a handful of near-misses. During one anticipated occultation in 1980, the star was occulted not by the planet but by its moon, Charon. In August 1985 three Israeli astronomers reported that they saw Pluto pass over a star, a claim that has been contested by other planetary experts. So the event predicted for the night of June 9, 1988—the one we were tracking down—would be an astronomical first.

One reason for the dearth of occultations involving Pluto is that the planet plods very slowly across the sky, circling the sun only once in two and a half centuries. Furthermore, astronomers have for decades been uncertain about its exact location in the sky. Since NASA doesn't dispatch the KAO on $125,000 missions just on a hunch, Elliot, Dunham, and other observers had devoted thousands of hours to the prediction effort. If they were right, the 1,400-mile-wide shadow cast by Pluto would sweep east to west over the South Pacific at more than 11 miles per second. But if their positions for either Pluto or the star known simply as P8 were wrong—even by a few millionths of a degree—the occultation's path could be off by hundreds of miles or, worse, miss Earth entirely.

It was precisely the combination of risk and potential scientific windfall that Elliot and Dunham found most challenging. "We wanted to do something hard," Elliot said, "and the only thing left was Pluto." Hard indeed. Astronomers searched for a ninth planet for decades before farmer-turned-astronomer Clyde Tombaugh spotted it in 1930. Charon, Pluto's lone known satellite, wasn't discovered until 10 years ago, and that was by accident. Virtually everything we know—or think we know—about Pluto is open to question, even such essentials as its diameter. Consequently, any new revelations about this far-flung world could radically alter astronomers' perceptions about it. An occultation, if recorded carefully, could provide the observational grist to keep theorists busy for years.

At the rear of the KAO I found Amanda Bosh and Leslie Young hunched over computer terminals, grinding out last-minute positions of Pluto and P8. Up front, Steve Slivan pounded data into another keyboard. All three were members of the "student armada" that had become indispensable to Elliot and Dunham. Slivan, for example, spent many cold nights atop Mauna Kea in Hawaii taking high-precision photographs of Pluto to aid in predicting the occultation.

We crossed the equator without ceremony three hours into the flight. Navigator Gene Moniz paid a visit from the flight deck to say that we'd made up some time and were now only seven minutes behind schedule. But soon his optimism soured. The headwinds had stiffened to nearly 115 mph—twice what had been allowed for. No one seemed very surprised; weather forecasts for that part of the Pacific are notoriously unreliable.

If Elliot and Dunham's predictions were right, the center of the shadow's path would cross Earth a bit more than 21 degrees south of the equator. And to get the most data possible, the KAO had to be positioned directly along the occultation's center line. But now it was certain that we would not get there in time. Closing up the telescope's viewing port would reduce drag and might bring the KAO farther south, but for best results the optics needed to be at the temperature of the outside air. Elliot and Dunham weighed their options. They chose to keep the port open and settled for a spot about one degree north of their planned position.

Brockett swung the airplane around sharply so that the telescope's operator could lock onto Pluto high in the northwest sky. Stars wheeled across the television screens, then settled into a familiar pattern. Only minutes from the event's predicted time, the light from Pluto and the star had merged into a single blip.

The rock-steady star field on the screen testified that the tracking was perfect. Up ahead, the telescope nodded and lurched visibly to counteract the airplane's motion. Bolted into place at its focus was Dunham's sophisticated imaging system, nicknamed Snapshot, which would record how much light was reaching the telescope. P8 was four times brighter than Pluto, so its disappearance behind the planet would be obvious—or so the astronomers hoped.

Dunham paused to write "The real thing!" in his notebook, then returned to staring at the display with the rest of us. The star-planet pinpoint seemed to twinkle momentarily, then gradually dim over about 10 seconds. A minute later, the light slowly regained its previous brightness.

The occultation was over. For 80 seconds, P8 was blotted from the sky by a frigid little world 2.7 billion miles away.

In quick succession I glanced at the clock (10:38 Universal time), the altimeter (40,800 feet), and the navigation display (20° 15′ south, 170° 33′ west). Whoops of excitement and applause filled the cabin. Slivan broke out a bag of cookies, Bosh a bag of freeze-dried "celebratory squid." I opted for the cookies.

Elliot, all smiles, made the hoped-for announcement: "Pluto probably has an atmosphere." He threw the "probably" in just to be cautious, but the gradual dimming and brightening had been unmistakable. If Pluto were an airless body, like an asteroid, the changes in brightness would have been instantaneous. A detailed playback of the computer tapes would ultimately be necessary, but for the moment it appeared that decades of debate over the existence of gas around Pluto were over.

It was 1 a.m. local time when the C-141 touched down at Pago Pago in American Samoa. A bus drove us through the dank darkness to the island's lone hotel, the Rainmaker. Standing by the cooling water of its reefed-in lagoon, I made one last survey of the southern sky before heading for my room.

Although too faint to be seen, Pluto was up there, somewhere, about to set in the northwest. Even in the largest telescopes Pluto is nothing more than a mysterious pinpoint of light. But tonight all that changed—Pluto had become a real world, a *place.*

—J. Kelly Beatty

Pilot Playground

If aviators had their own Disneyland, it would be Mojave Airport.

by Patricia Trenner *Photographs by James Sugar/Black Star*

One sunny day last June, the Santa Ana winds blasted down Southern California's Tehachapi Mountains, whirling the rotors of 4,000 windmills set on the ridges until their blades were a white blur. Down below, at Mojave Airport, the anemometer read 80 mph, and tower controller John Noga folded up his Los Angeles Times, stowed his radio handset, and wound his way down the tower's wooden staircase. There

Tower controller John Noga, the grand marshall of Mojave's air traffic parade, watches over the early morning launch of a target drone.

A European Airbus A-300 testing a General Electric engine obeys the "follow me" sign on Sabovich's Cadillac.

Airport manager Dan Sabovich once grew alfalfa and onions but now cultivates a diverse crop of aerospace enterprises.

would be no more takeoffs or landings at Mojave that day. For the rest of the afternoon, the only sound at the airport aside from the wind was the rattling of the hangar doors. For the rest of the afternoon, the only sound at the airport aside from the wind was the rattling of the hangar doors.

But the next morning, with the anemometer reading a sedate 25 mph, the airport came alive again. Malevolent-looking Blackhawk military helicopters hovered over the sand and scrub between the runways. An amateur airplane builder rolled out an elaborately painted Christen Eagle biplane, nearly four years in the making, for its first flight. A matte-black B-1B bomber from neighboring Edwards Air Force Base with an F-111 and a T-38 flying chase knifed overhead, the *whump* of their sonic booms shaking the buildings lining Mojave's main runway. A privately owned Hughes 500 helicopter lifted off on a solo flight to the North Pole.

A hundred years ago the only sounds in this high desert were the braying of mule teams and the creak of wagons hauling boron ore from Death Valley to the Southern Pacific and Santa Fe railhead at Mojave. Today, Southern

Pacific stores its unused freight cars along the airport perimeter.

The town of Mojave—population 4,000—clings to the intersection of two major thoroughfares. Night and day, produce-laden trucks from Bakersfield negotiate the steep slopes of Highway 58's Tehachapi Pass and downshift into Mojave bound for points east or veer right onto Highway 14 to Los Angeles, 75 miles south.

The same climate that discourages farming in the desolate Antelope Valley nurtures the region's sole export: aerospace enterprises thrive year-round in the clear air and on the dry lakebeds that serve as runways. Land and labor are fairly cheap on this sparsely populated plain, where residents regard sonic booms as the sound of a healthy local economy.

Mojave's airport began operations as a Marine Corps airbase in 1942. When the Marines bailed out after the war, they gave the airport to Kern County, which found no use for it and eventually put it up for rent in the late 1960s.

Thompson's Market, which celebrates low prices and high fliers, entered the catering business when it served 2,600 VIPs at a reception for the Voyager.

Aviators World buys and sells vintage aviation paraphernalia. It set up shop in Mojave after being forced out of the New York City area by high overhead costs.

Buzz Sawyer's homebuilt aircraft form a maze in his crowded hangar. One, the world's only Skyjacker Supersport, is a twin-boom pusher built of cardboard. The airplane—with pilot—weighs 500 pounds.

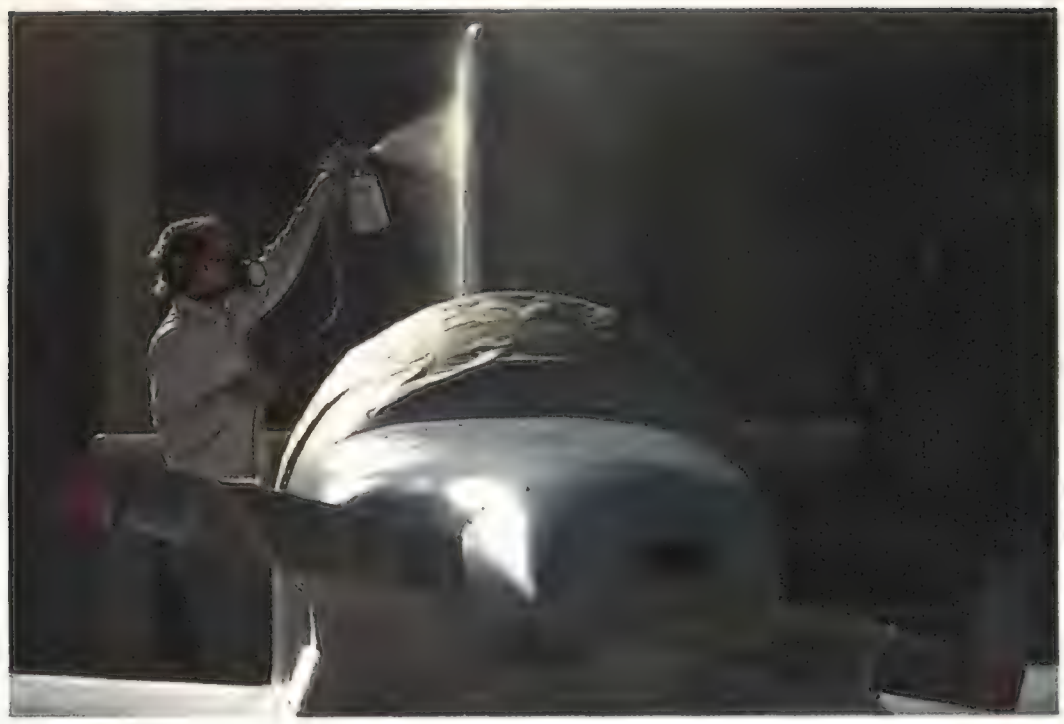
Back then Dan Sabovich was a middle-aged Bakersfield farmer with a single-engine Cessna and friends at Edwards who liked to roar over his alfalfa and cotton fields at 50 feet in F-100s, B-52s, and U-2s. Sabovich saw the potential in Mojave's long runways, which were crumbling under the weight of DC-8s and 707s dropping in for practice takeoffs and landings. He started campaigning for the creation of an independent county organization to manage the airport after deals between prospective renters and the local government fell through. In 1972 he was named general manager of the newly formed East Kern Airport District.

Sabovich set out to turn the airport's 3,000 acres into a civilian version of flight-test facilities like Edwards and nearby Palmdale's Air Force Plant 42. He started by leasing a taxiway to a farmer who needed the space to dry 700 tons of grapes into raisins. Soon he lured heavier hitters. Today, the locals promote Mojave as the nation's primary civilian flight-test center. General Electric, one of the first tenants, is now testing its

American Jet stores old airliners in a "boneyard," selling off parts until nothing remains but scrap aluminum.

unducted-fan engine on a 727 and an MD-80; another testbed, a 707, casts a huge but graceful shadow on the ramp. Burt Rutan, designer of innovative aircraft, including the *Voyager,* recently equipped his hangar with a gym, racquetball courts, and a Jacuzzi to lure top-flight employees. One of Rutan's latest projects, a lightweight business jet built for Beech Aircraft, made its first flight last July with a Rutan Long-EZ flying chase. Tracor Flight Systems, which snatched up the *Voyager* hangar once the airplane left for the National Air and Space Museum, converts outdated fighters—F-86s, -100s, -106s—to target drones and is installing electronic warfare systems in Sikorsky EH-60 helicopters. Canadair came down from Montreal to do much of its flight-testing on the Challenger business jet. Europe's Airbus

Outdated F-100 fighters are readied for a brief reincarnation as target drones. In the Flight Systems hangar, their tails are painted crimson to enhance their visibility.



Gordon Olsen takes advantage of a calm day to put the finishing touches on his highly modified Pursuit, one of his nine homebuilt aircraft.

Machinist Danny Sanders drives up from Los Angeles every weekend to work on his Stolp Starduster Too.

Industrie and General Electric brought in an A-300 airliner to test a high-power version of GE's CF6-80C2 turbofan. The National Civilian Test Pilot School built a hangar at the east end of the row to house its French-built Paris and Spanish CASA jets, de Havilland Dove, and two Chipmunk aerobatic trainers. Northrop, Mojave's newest tenant, is assembling and flight-testing five F-5Es for sale to Singapore.

At the other end of the ramp are rows of yellow T-hangars housing Mojave's smaller tenants. Some have squeezed three and four homebuilt airplanes into the 40- by 50-foot aluminum interiors, along with a workbench, refrigerator, couch, and coffeepot. The people who design and build their own aircraft live in these hangars during the day and drop in at neighboring hangars between flights to scrounge up a cowling fastener and an iced tea. Outside one door, in a bucket next to a rundown bicycle, a scraggly tomato plant struggles for a toehold.

The ramp around the T-hangars is dotted with the rare and exotic, the old and the new. A pair of 1950s hollow-cheeked Saab Lansen jet fighters squats by the chain-link fence; an overly busy gunmetal-gray Gloster Meteor from the '40s peers at the runway. An insect-like Long-EZ rolls toward the taxiway, wings and canard twitching in the breeze. Sabovich preflights his classic Beechcraft Bonanza, which stands out in this crowd like a bank manager at a heavy metal concert.

Sabovich chose to develop only the south

Three-year-old Drew Gaston contemplates an inevitable career path: his father is a B-1B test pilot, his mother was a flight attendant, and his grandfather manages Mojave Airport.

Canards and winglets identify a flight of Rutan designs—Defiant, Model 144, Long-EZ, and Grizzly (left to right)—framed against the Tehachapi Mountains.

side of the airport, leaving most of the land surrounding the three runways open. The dry desert air acts as a natural storage vault for a long line of old Convair transports and the remains of scavenged airliners. A patch of land off the approach end of Runway 30 is leased to an ongoing parade of crews working on movies, TV series, and commercials. The outtakes document the trials and errors of imaginative advertising—Sabovich has a snapshot of a flattened sedan that succumbed during the shooting of an ad featuring a truck perched on its roof.

As the airport fills up with new business, so do the tills of Thompson's Market, the Imperial Inn No. 131, Jerry's Restaurant, and the rest of Mojave's businesses. Virtually all have on their walls photos of *Voyager* and its pilots, Sabovich, and a few of the Air Force projects that rattle their windows daily. And on weekends, parents bring the kids out to see the historic, colorful, and quirky aircraft that could coexist only at Mojave.

Campaign '88 Is No Space Race

Vote for the space program of your choice: undefined or undecided.

Robert Bazell
science correspondent,
NBC News

Space is not a major issue in the 1988 presidential race. Campaign aides whose job is to determine the public mood say that Americans value a space program, but not enough to consider it a significant factor in their choice for the presidency.

Three circumstances have conspired to force space policy out of the election: the concern about the federal deficit, the failure of the Reagan administration to establish a credible, long-term goal for space exploration, and the emergence of two candidates who are not inspired by the space adventure. Space means spending, and although Americans want a space program, there is no national purpose, such as the establishment of a lunar colony or a trip to Mars; no visible accomplishment, such as an orbiting space station or platform; and no charismatic or persuasive advocate to entice them to pay for it.

Neither candidate has a vision for NASA's future.

The state of space policy that President Reagan is bequeathing to his successor is best illustrated by the stalled space station. Five years ago the president declared that the United States would fly a space station; so far not a single piece of hardware has been built. The pace of the space program in the Kennedy-Johnson era underscores this sluggishness. Eight years after President Kennedy said that America would go to the moon, Neil Armstrong's boot touched the lunar surface.

This year the space station has been the victim of Washington power struggles and confused policies within the administration. In an announcement by the White House last February 11, the president promised to ask Congress for $1 billion for the manned space station in fiscal year 1989. In the same statement he undercut the program by committing NASA funds to a private unmanned facility, viewed by NASA management as station competition. This summer Congressional proponents of the NASA version fought off several attempts to kill the project and finally reached a compromise: funding the station at the requested level but withholding half the money until May 15, 1989. By that time the next president will presumably have decided what to do. But as of this writing, the future of the space station is undecided.

A major cause of the ambivalence is that NASA has never given a clear picture of what the space station is supposed to accomplish. Critics charge that it will provide little beyond employment at NASA and profits for its contractors. Proponents reply that a station is "the next logical step" toward whatever the United States will do in space. But until "whatever" is converted to tangible missions and the need for the space station is articulated in terms of support for them, the space program will continue to drift.

Neither George Bush nor Michael Dukakis has come up with a significant vision for NASA's future. Both candidates spelled out their space policies in speeches at the agency's Marshall Space Flight Center in Huntsville, Alabama, and there was no shortage of rhetoric. Dukakis said that President Kennedy "raised the stars and stripes so high they literally reached the moon." Bush declared, "In very basic ways, our exploration of space defines us as a people." Despite these words, neither man articulated a long-term plan to

The International Airplane

AIR&SPACE
Smithsonian

by Martha M. Hamilton

THE JET SET

When McDonnell Douglas sells an MD-80, the updated version of its medium-range DC-9 airliner, the sale is chalked up on the U.S. side of the balance-of-payments ledger.

In fact, however, this American product is an international airplane: the wings, the entire tail section, and most of the vertical and horizontal stabilizers are made by McDonnell Douglas of Canada. Aeritalia of Italy furnishes fuselage panels. The elevators are made by Hawker de Havilland of Australia, while SAAB-Scania of Sweden contributes wing flight control surfaces. The overwing emergency exit doors are by CASA of Spain. Swiss Federal manufactures portions of the wings' leading edges, and Mitsubishi makes wing components. Many electronic components are produced in Great Britain or elsewhere in Europe. Some of the nosewheel doors and main landing gear doors are made in China. In the early 1990s, China's contributions will include some complete nose sections and horizontal stabilizers. The lavatories are made in Japan.

The picture is a complex one but by no means is it unusual. "I don't think there's a major airframe or engine program undertaking now that is not international in some way," says Edward C. Bursk, director of international programs for Raytheon and chairman of the Aerospace Industries Association's (AIA) international council.

The international airplane is the result of unprecedented competition for aircraft sales that has grown in nearly inverse proportion to the number of major manufacturers left on the bloody battlefield of this risky, high-stakes business. "The internationalization of airplanes that has been taking place in the last five years is an acceleration of a trend going back almost 20 years," says Paul Osborne, manager of government affairs and international business for Boeing.

The same factors that have shrunk the ranks of the manufacturers also have produced international commercial ventures that couldn't have been imagined 20 years ago. Faced with the enormous costs and risks involved in developing an aircraft, a shift in the market away from the United States, and the economic nationalism and strategic concerns that induce buyer nations to maintain their own aircraft industries, aircraft manufacturers have responded by creating a complex web of international arrangements.

In the aircraft industry, where it's no plane, no gain, manufacturers will go to extraordinary lengths to make a deal. The subcontracting relationships that have evolved include indirect subsidies for purchases, international underwriting of financial risks, guarantees of job generation, and other subtler, national "goodwill" gestures.

"It's a marketing ploy," says Paul H. Nisbet, an industry analyst with Prudential-Bache. "It's a spread-the-wealth or spread-the-cost ploy, and it's a balance-of-payments ploy."

As a marketing ploy, the practice of buying parts from another country is aimed at giving the supplier nation a stake in the aircraft program, with the hoped-for result of greater sales to that country. As a result, the world's three major commercial aircraft manufacturers, Boeing, McDonnell Douglas, and the European consortium Airbus Industrie, "have become essentially assemblers of parts produced around the world," says Alan Boyd, chairman of Airbus Industrie of North America.

The relationships aerospace manufacturers are fostering with their foreign subcontractors extend well beyond simple supplier agreements. For example:

- Continuing to build a relationship that the company hopes will pay off in sales, the Netherlands' Fokker Aircraft recently signed

an agreement with the Indonesian aircraft firm IPTN (Industri Pesawat Terbang Nusantara) to produce parts for the Fokker 100 airliner. Fokker had laid groundwork for such an arrangement by agreeing in 1985 to hire a handful of Indonesian aeronautical graduates.

• In the late 1960s, McDonnell Douglas, eager to sell DC-9s to Yugoslavia, agreed to help the Baltic nation market exports, including wine and canned ham, in the United States—a deal known as an offset. The international export agency set up in Long Beach works with McDonnell Douglas employees to help Yugoslavia earn dollars to spend on airplanes.

• General Dynamics, seeking to persuade Norway, Denmark, the Netherlands, and Belgium to buy and co-produce the F-16 in the early 1970s, used a high-powered "sales team" including Department of Defense officials and the U.S. ambassadors and military attachés in those nations. The U.S. officials had several reasons for being interested in the sale, including increasing the uniformity of weapons in NATO countries and improving the U.S. balance of payments. Still, the sales pitch met resistance from the Belgians until the U.S. government agreed to purchase $30 million worth of machine guns from a Belgian arms firm, according to several accounts.

Douglas Aircraft Company

Douglas Aircraft Company

Waiting in the wings, some of Canada's many contributions to the MD-80 will soon be united with flaps and fuselage.

McDonnell Douglas MD-80

Length: 130′ 4″ (39.72 m)

Wingspan: 107′ 10″ (32.86 m)

Height: 29′ 8″ (9.04 m) (dimensions are for smaller versions)

Max. takeoff weight: 140,000 lbs.

Top cruise speed: 575 mph

Seating: 172 (in short-route service)

Max. range: 1,800 statute miles (2,730 for MD-87 version)

Ceiling: 37,000 ft

Engines: Two Pratt & Whitney JT8D-217As, JT8D-217Cs, or JT8D-219s

Approximate price: $23–26 million

The lengths to which manufacturers have gone to make sales have raised some questions, since offsets and other deals can cut into the overall value of the sales. For example, in 1976 Northrop firmed up a deal to sell F-5 fighters to the Swiss by agreeing to help that country sell some of its products in the U.S. Although Northrop does not publicly disclose details of its offset agreements, industry rumors placed that offset at approximately 140 percent of the total price of the aircraft and engine.

But defenders of the practice argue that such arrangements are beneficial to the United States overall. U.S. aerospace exports, which totaled nearly $25 billion in 1987, are a major plus in the U.S. trade balance of payments. "To the extent that arms sales would not take place in the absence of offsets, sales with offsets have net economic benefits for the U.S. as compared with no sales at all," one U.S. Office of Management and Budget assessment concluded.

Making sales abroad has become increasingly critical for U.S. aircraft manufacturers. For instance, according to a 1987 analysis, Boeing's export sales have ranged from 42 to 62 percent of

its total sales during the 1980s. And market growth has increasingly shifted abroad; AIA-compiled statistics place approximately two-thirds of the market for commercial transports outside the United States. "There isn't any question in my mind that international cooperation is required [for the U.S. industry] to maintain our competitive advantage," the AIA's Bursk says.

Yet aircraft manufacturers often choose to downplay the tremendous role creative deal-making plays. "In aerospace, if we win it's always because we have the best product. If we lose, it's always because of unfair foreign competition," says one aircraft manufacturing executive, tongue firmly in cheek.

The nature of foreign competition in aircraft manufacturing remains a highly volatile issue. For political and marketing reasons, Airbus is quick to offset its portrayal by competitors as a heavily subsidized foreign adversary by pointing out that the U.S. content of its airplanes can be as high as 30 percent. The European consortium has bought approximately $3.5 billion worth of U.S.-manufactured aircraft components since 1978.

Recently Textron Aerostructures of Nashville, Tennessee, signed an agreement with British Aerospace to produce portions of the wing that BAe, an Airbus partner, builds for Airbus' twin-engine A330 and four-engine A340—work that is expected to generate approximately $700 million for Textron over the life of the program. In addition, "every Airbus airplane flying has got the Rohr nacelle from good old Chula Vista, California, and I think most of our planes have Sperry [now part of Honeywell, another U.S. firm] avionics," says Airbus' Boyd.

Aside from the marketing benefits they offer, international cooperative ventures are also an attractive way to spread the financial risks that come with developing, building, and selling aircraft. "I think the enormous cost of these programs and the fact that there is not enough to go around are the real drivers of cooperation," says Virginia Lopez, director of the Aerospace Research Center and a co-author of a comprehensive report on the subject for the AIA.

Launching a new aircraft program these days requires that billions of dollars be spent before any return on the investment is in sight—burdens only an industrial giant can bear. These staggering up-front costs were the force behind the reduction of the ranks of the aircraft manufacturing industry from at least 10 major players

British Aerospace

British Aerospace ATP

Length: 85′ 4″ (26.00 m)

Wingspan: 100′ 6″ (30.63 m)

Height: 23′ 5″ (7.13 m)

Max. takeoff weight: 49,500 lbs.

Top cruise speed: 308 mph

Max. seating: 72

Max. range: 2,530 statute miles

Ceiling: 25,000 ft

Engines: Two Pratt & Whitney of Canada PW124A/125A three-shaft turboprops

Approximate price: $10.5 million

British Aerospace

Hulking and expressionless, British-built fuselages in BAe's Manchester, England factory have yet to acquire some of the ATP's international flair.

in the 1950s to three. Even Boeing has had close calls.

The Boeing 747, which cost $1 billion to develop, was the world's first wide-body jet when it was launched in the early 1970s. But a recession had temporarily wiped out the market for commercial airliners. Boeing was forced to take drastic measures, including slashing its workforce from 105,000 to 38,000. Tex Boullioun, then president of Boeing's commercial aircraft subsidiary, was quoted at the time as saying the firm "came within a gnat's whisker of not making it."

Many of the burdens that have contributed to the internationalization of commercial aircraft are likewise shaping military aircraft development, in which the push for NATO "interoperability"—consistency in equipment among NATO allies—and more intense worldwide competition in the armament market have played pivotal roles.

NATO's European members have united to produce European products for the alliance, such as the Panavia Tornado fighter produced by a partnership of British Aerospace, the West German firm Messerschmitt-Bölkow-Blohm, and Italy's Aeritalia. At the same time, U.S. manufacturers such as General Dynamics have emphasized co-production. More than 400 F-16s have been delivered from European assembly lines over a 12-year period, and European parts manufacturers and aircraft assemblers have also benefited from sales of the aircraft outside NATO.

International cost-sharing ventures have allowed some nations to break away from cumbersome government procedures that slowed down aircraft programs and added to their costs. According to Leo J. Schefer, a former spokesman for British Aerospace, one impetus behind the joint Experimental Aircraft Program was an experience British Aerospace had in the late 1970s: the aircraft company's proposal for an air superiority fighter was met with a request from the British Treasury to come back with an airplane that would be 10 percent cheaper at the expense of some capability. Unfortunately, a 10 percent increase in costs during the year in which the program was revised meant that inflation erased the savings from the capability reduction, Schefer says.

Because engines are the most costly system on any aircraft, their influence on the international makeup is proportional. "Today, from around 10 percent up to 30 percent of our planes are non-U.S. content, depending upon the engine" the customer

Boeing Commercial Airplane Company

Boeing 747-400

Length: 231′ 10″ (70.66 m)

Wingspan: 211′ (64.31 m)

Height: 63′ 5″ (19.32 m)

Max. takeoff weight: 850,000 lbs.

Top cruise speed: Mach .84

Max. seating: 550 (short-range version)

Max. range: 8,410 statute miles (with 420 passengers)

Ceiling: 45,100 ft

Engines: Four Pratt & Whitney PW4056s, GE CF6-80C2s, or Rolls-Royce RB211-524Gs

Approximate price: $110–129 million

Boeing Commercial Airplane Company

While the 747-400's vertical winglet is U.S.-built, the six-foot wing extension in front of it comes from South Korea.

chooses, says Boeing's Osborne. "If you take a 747 and put a Rolls-Royce engine on it, the foreign content goes up from 5 to 25 percent."

The same factors that have contributed to the making of an international airplane have also created an international airplane engine. One of the most successful joint ventures has been the alliance of General Electric and France's SNECMA to form CFM International. The partnership began in late 1971 with the CFM56, an engine now producing up to 30,600 pounds of thrust. The project weathered initial difficulties, including a delay in startup because of U.S. government concerns about technology transfer—a major sticking point in many international ventures.

The problem—the engine would use a core developed by GE for military use—was eventually resolved through discussions that reached as high as the French and American presidents. It was not until 1973 that the U.S. government accepted. And then there was another wait before the first customer signed on. "It was not till 1979 that we got our first order. We were starting to be desperate at the time," CFM chairman Jean Bilien recalls. Before several airlines, including United and Delta, chose the engine to refit their DC-8s, the partners had spent "several hundreds of millions," according to Bilien. "Without the DC-8, we might have closed the program."

Since then, CFM has settled into a comfortable and successful relationship with its partners selling a family of engines for commercial aircraft. The partnership's CFM56-3 is the only engine offered on Boeing's 737-300, which has become one of the best selling airplanes in the world. Although GE and SNECMA sell and market other engines independently, "we are partners on all commercial engines from 25,000 to 60,000 pounds of thrust, so there is no conflict between the partners," Bilien notes.

As international relationships develop, the role of foreign partners is becoming more substantial. For instance, Japan Air Lines was the largest customer for the Boeing 747, and Japan supplied parts for that airplane. With the 767, however, the Japanese firms took on a bigger role: they became risk-sharing partners. The Japanese firms were responsible for the engineering and design work, including the tooling and designing necessary to produce the project.

Boeing's next program, the development of a fuel-efficient airplane until recently called the 7J7,

Saab Aircraft

SAAB JAS 39 Gripen

Length: 46′ 3″ (14.09 m)

Wingspan: 26′ 3″ (8 m)

Height: 15′ 5″ (4.69 m)

Max. takeoff weight: 17,635 lbs.

Top speed: supersonic at all altitudes

Seating: one (pilot only)

Max. range: classified

Ceiling: classified

Engines: One RM12 (Volvo Flygmotor derivative of GE F404)

Approximate price: $15–20 million

Saab Aircraft

British Aerospace contributed composite wings for the first three prototypes of Sweden's newest fighter; Sweden will manufacture the rest.

should involve a still larger role for the Japanese Commercial Aircraft Corporation, made up of Kawasaki, Mitsubishi, and Fuji. The Japanese consortium is slated to be a 25 percent full-equity partner in that program. However, relatively low oil prices, which are slowing the development of a market for that next-stage aircraft, have resulted in the program's being scaled down to research alone for the time being.

The Japanese will also play a large role in a General Dynamics program by spending some $4 billion to come up with their own improvements to the F-16. The United States will be on the receiving end of the technology flow, which is currently under negotiation, and a 30 to 40 percent share of the work on the new product is expected to be performed in the U.S.

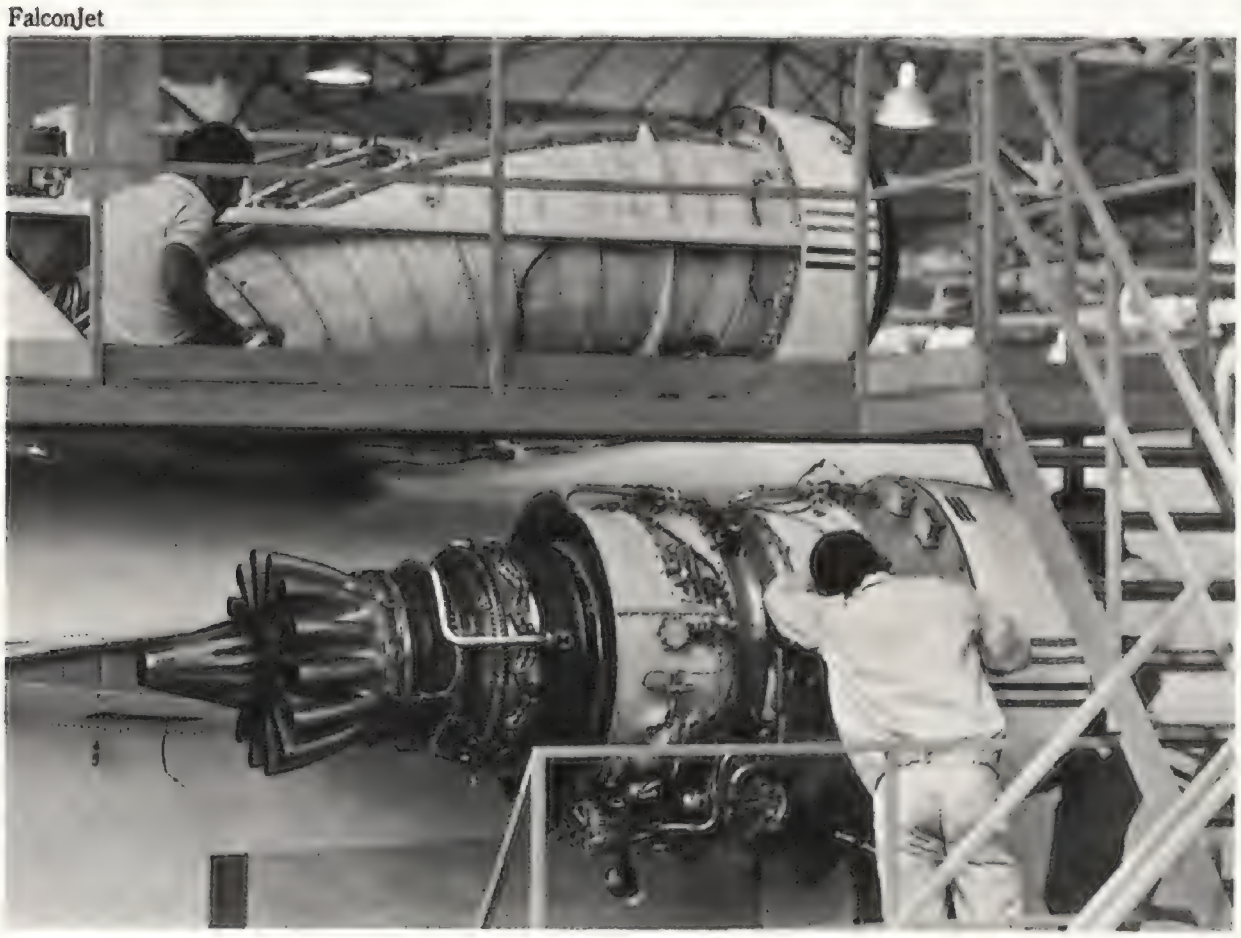
Despite the increasing role of Japan in aircraft programs, aerospace officials say they don't expect the U.S. industry to be overpowered in the same way as the auto and steel industries were—as long as the United States can keep its technological edge.

"Sure, it makes a contribution to the other country's technical base. That's why they're interested in the beginning," says the AIA's Bursk. "But clearly in a world now where there is such communication of technological information, it doesn't make a lot of sense to sit on technology and to refuse to trade it and watch competitors develop it. You have to trade technology, but you can only afford to do that if you're working on the next generation and staying ahead of the curve."

One prospective venture would tie together two of the three remaining giants in commercial aircraft manufacturing: Airbus and McDonnell Douglas are engaged in a series of negotiations to seek a joint project. Task forces from the two companies meet regularly to discuss the problems inherent in such a venture, including how the two companies could market a product jointly and then approach the same purchasers and market other projects as competitors. Says Airbus' Boyd, "Boeing ought to be very happy that Airbus and McDonnell Douglas are trying to work their way through this thing; it's taking a lot of management time."

That Airbus and McDonnell Douglas are, as Boyd notes, "bitter competitors" makes the situation a very complex one indeed. "It would be like U.S. Grant and Robert E. Lee being asked to share the same bed in a motel prior to Appomattox," Boyd says. "I doubt that either of them would get a hell of a lot of sleep."

FalconJet



Dassault-Breguet Falcon 900

Length: 66′ 4″ (20.21 m)
Wingspan: 63′ 5″ (19.32 m)
Height: 24′ 9″ (7.54 m)
Max. takeoff weight: 45,500 lbs.
Top cruise speed: 583 mph
Seating: 19 (plus two crew)
Max. range: 4,836 statute miles
Ceiling: 51,000 ft
Engines: Three Garrett TFE731-5A-1Cs
Approximate price: $19 million

FalconJet

A Falcon 900 meets its engines at Dassault's production/ completion facility in Little Rock, Arkansas.

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**Based on '88 model year sales by nameplate through March. ** See this powertrain limited warranty & its restrictions at dealer. †Available 2/89. ††See dealer for option restrictions and requirements.*

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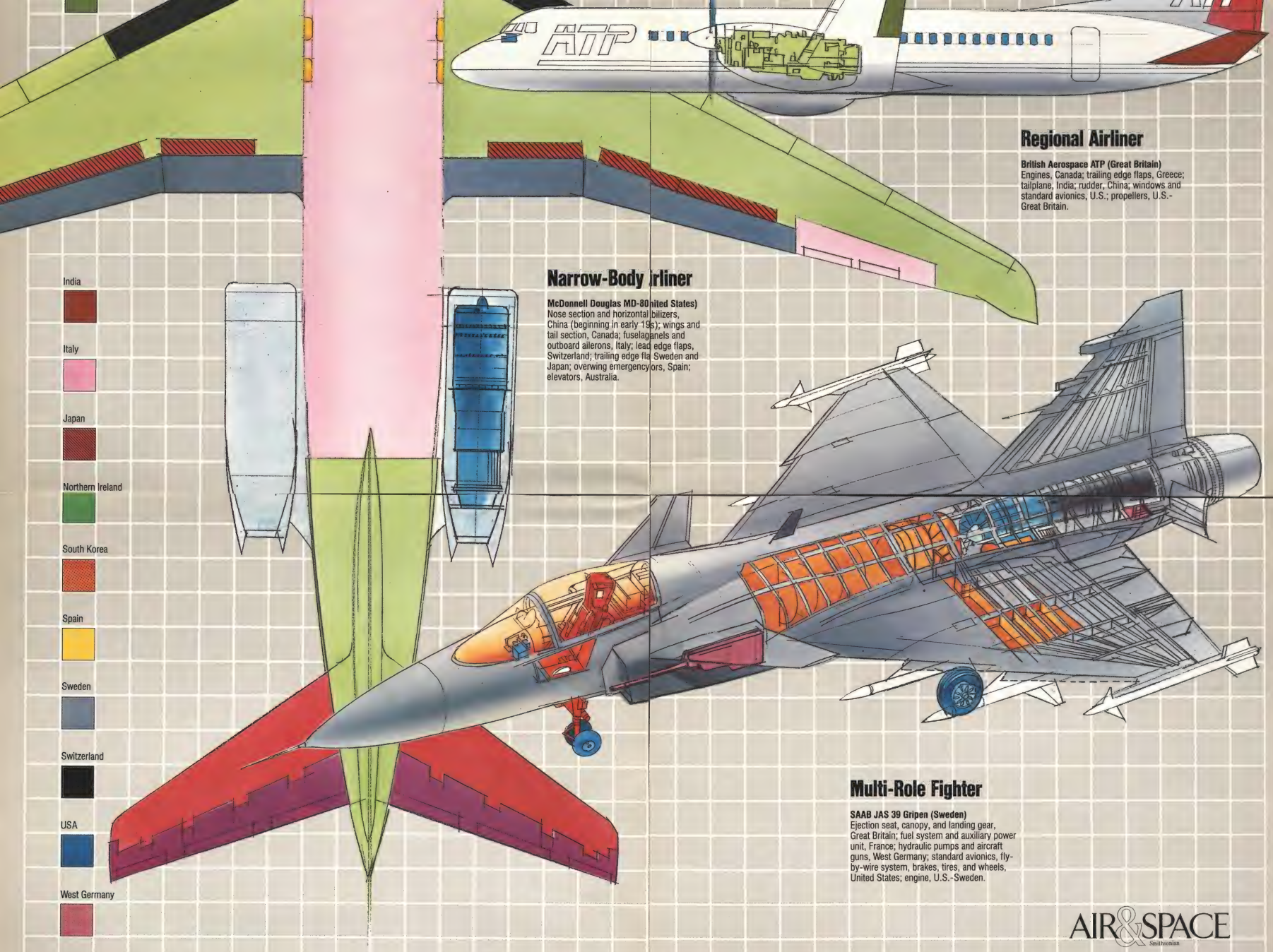


Regional Airliner

British Aerospace ATP (Great Britain)
Engines, Canada; trailing edge flaps, Greece; tailplane, India; rudder, China; windows and standard avionics, U.S.; propellers, U.S.-Great Britain.

India

Italy

Japan

Northern Ireland

South Korea

Spain

Sweden

Switzerland

USA

West Germany

Narrow-Body Airliner

McDonnell Douglas MD-80 (United States)
Nose section and horizontal stabilizers, China (beginning in early 1985); wings and tail section, Canada; fuselage panels and outboard ailerons, Italy; leading edge flaps, Switzerland; trailing edge flaps, Sweden and Japan; overwing emergency doors, Spain; elevators, Australia.

Multi-Role Fighter

SAAB JAS 39 Gripen (Sweden)
Ejection seat, canopy, and landing gear, Great Britain; fuel system and auxiliary power unit, France; hydraulic pumps and aircraft guns, West Germany; standard avionics, fly-by-wire system, brakes, tires, and wheels, United States; engine, U.S.-Sweden.

AIR&SPACE Smithsonian

 Illustrations: Paul Salmon Design: Phil Jordan and Associates Editor: Karen Jensen

The International Airplane poster depicts aircraft representative of five categories. Each aircraft shown is currently in production, and unless otherwise indicated, the manufacturer's nation of origin is the source of the airframe. The illustrations (not to scale) are intended to indicate the range of international involvement in each aircraft and are not necessarily complete representations of the international composition.

The International Airplane

Beneath the sleek metal skin of most aircraft lies a machine of many colors. Today these aircraft are not so much built as they are assembled—and the parts come from many different nations. A product of unprecedented levels of competition and risk, the airplane has become increasingly international in the last five years. The trend is likely to continue in the years to come.

Australia

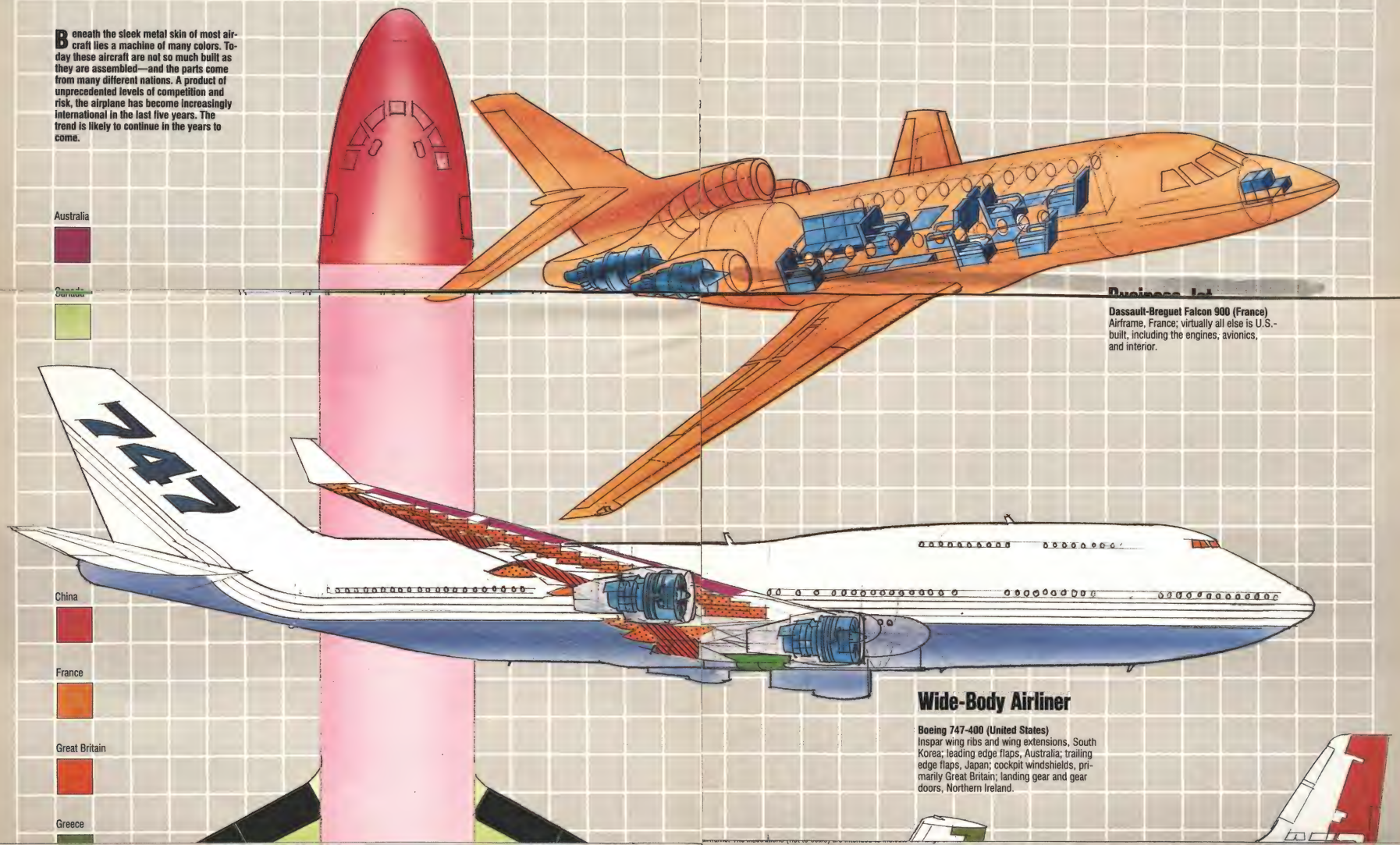
Canada

China

France

Great Britain

Greece



Dassault-Breguet Falcon 900 (France)
Airframe, France; virtually all else is U.S.-built, including the engines, avionics, and interior.

Wide-Body Airliner

Boeing 747-400 (United States)
Inspar wing ribs and wing extensions, South Korea; leading edge flaps, Australia; trailing edge flaps, Japan; cockpit windshields, primarily Great Britain; landing gear and gear doors, Northern Ireland.

guide the space program. Both said they would reestablish a National Space Council, headed by the vice president, to do that.

Bush identified three immediate goals for the U.S. space program in his speech last October. The first was "Mission to Planet Earth," an extensive Earth observation project advocated by former astronaut Sally Ride in a report to NASA last year.

"Let us remember," Bush said, "as we chase our dreams into the stars that our first responsibility is to our Earth, to our children, to ourselves."

Bush did not say he advocated Ride's specific plan, which calls for nine huge orbiting platforms (four to be provided by Europe and Japan) that would be assembled at the space station. Indeed, one can argue that NASA is already carrying out a "mission to planet Earth" with its studies of ozone depletion, climate changes, and many satellite observations of Earth's surface.

The budget must be cut, and space is a tempting target.

Bush also gave his support to the development of an unmanned heavy-lift launch vehicle and the use of space for strategic defense. In addition, he said that the United States "should make a long-term commitment to manned and unmanned exploration of the solar system." Some of this, he said, could be done in cooperation with other countries, including the Soviet Union. He offered no specifics about any of these suggestions.

Bush stepped around the space station issue. He said that "NASA should remain the lead agency in exploring the frontiers of space science and technology—from development of a transatmospheric vehicle to construction of a space station." He did not say when one should be built, or whether it should be the $30 billion version NASA wants or something smaller, such as a man-tended station. Bush's aides repeat that all specifics of the space program will be worked out by the National Space Council after the election.

The only specific program supported by Dukakis when he addressed the space center in late August was "the development of a permanently manned space station." The announcement marked a reversal of his previous policy. Earlier in the campaign, Dukakis had shown little interest in space, declining several invitations to speak on the subject. He first suggested that an economy model might be in order for the space station. "There are a number of less costly alternatives," an early position paper said, "including a station that need not be permanently manned."

But in Huntsville, Dukakis called the manned station "essential" for ambitious undertakings in space. "A space station can answer fundamental questions about the effects of long-term spaceflight on crew members and eventually serve as a staging base for [a] longer voyage," he said.

Dukakis' shift came partly from simple political pressure. Sixty-five members of Congress wrote him a letter urging him to reconsider his first position and 18 met with his issues director, Chris Edley. His vice presidential candidate exerted a major influence. Lloyd Bentsen had been advocating a strong civilian space program for a long time. He sees space as relief for the economic pain that oil price decreases have inflicted on Texas. Last year, in an unusual move for a veteran Senator, he took a position as a junior member of the committee that authorizes the NASA budget so he could try to secure more money for the aerospace industry in general and for Texas in particular.

And there are other political realities to make Dukakis a believer in the space station. The aerospace industry sees four areas for big profits in the future: Star Wars, the new launch system, the space plane, and the space station. Since Dukakis is against the Strategic Defense Initiative and the space plane, he might have had trouble opposing the station as well, especially in the key states of Florida, Texas, and California, where significant amounts of wages and wealth flow from the aerospace industry.

Without a president who can defend space spending with reasons other than political expediency, the space program is not likely to compete well for a share of the budget. This year the discretionary portion for domestic programs, everything from highways and medical research to urban renewal, was $148 billion. The increasing deficit is pressuring Congress to cut that amount, and the $10 billion NASA budget is a tempting target.

For the past several years Senator William Proxmire of Wisconsin, the head of NASA's appropriation committee, has tried to reduce allocations for space. Proxmire's counterpart in the House, Edward Boland of Massachusetts, has managed to reinstate much of the money. Proxmire will be replaced this year by either Patrick Leahy of Vermont or Barbara Mikulski of Maryland. Both share Proxmire's desire to cut NASA funding. More important, Boland will be replaced by Bob Traxler of Michigan, who also takes a dim view of increases for NASA. The indecision that has kept space out of the election now threatens to take space out of the budget. ←

The Space Statesman

When Mikhail Gorbachev wants to talk about space, he turns to Roald Sagdeev.

by Nicholas Daniloff

As Moscow correspondent for *U.S. News and World Report* in the early '80s, I had come to expect the reticence of Soviet bureaucrats, who responded only occasionally when I asked for information. Then I met Roald Sagdeev.

For months I had been trying to interview a leading expert before filing a report on the Soviet space program. As usual, my deadline passed with no reply from the authorities. I filed and forgot. A month later, Sagdeev's office called. He would see me if I could report there within the hour.

Collecting thoughts and equipment, I jumped into the car and maneuvered over the snow-swept cobbles of Trade Union Street to the southeast edge of Moscow. There I found the oblong gray building, perhaps two football fields long and six stories high, that houses the institute known to the Soviets as IKI, for Institut Kosmicheskikh Issledovanii, the Space Research Institute.

After the usual meticulous checks at the gate, I was led up a flight of stairs, down long drafty corridors, past a winter garden of hothouse plants that was partly shielded by Victorian net curtains, and into a spacious office. Sagdeev (pronounced sog-DAY-ev) sat at a clean, blond-wood desk with four telephones, gray, cream, black, and red. The red one I imagined linked his office to the Kremlin. Behind him hung a large picture of the solar system and two circular charts of the northern and southern heavens; above these, the obligatory portrait of Lenin.

To my astonishment, Sagdeev jumped up from his desk and welcomed me. Another correspondent had already arrived. "Do sit down," he urged. "Make yourself at home. How about some black coffee and cookies before we get started?" He turned to an aide, who relayed the order.

Perhaps it was his politeness, or his cultivated speech. Maybe it was his ease with foreigners, or his informal dress and shaggy hair that made him seem instantly accessible. But on that November morning in 1983, long before Mikhail Gorbachev had come to power and made *glasnost* the policy of the state, I felt something in Moscow relax.

For the next three hours, as coffee was served in white china cups, Sagdeev expounded on international cooperation as a stimulus of science. The subject of the briefing was the Vega project, his plan to lead nine nations to Halley's Comet, expected in Earth's neighborhood in 1986 (see "Balloons Over Venus," June/July 1988). He was disappointed by Washington's reluctance to get involved.

"We would like a more active two-way cooperation with the United States," he said. "We did have contacts with our Venus probes and the Ameri-

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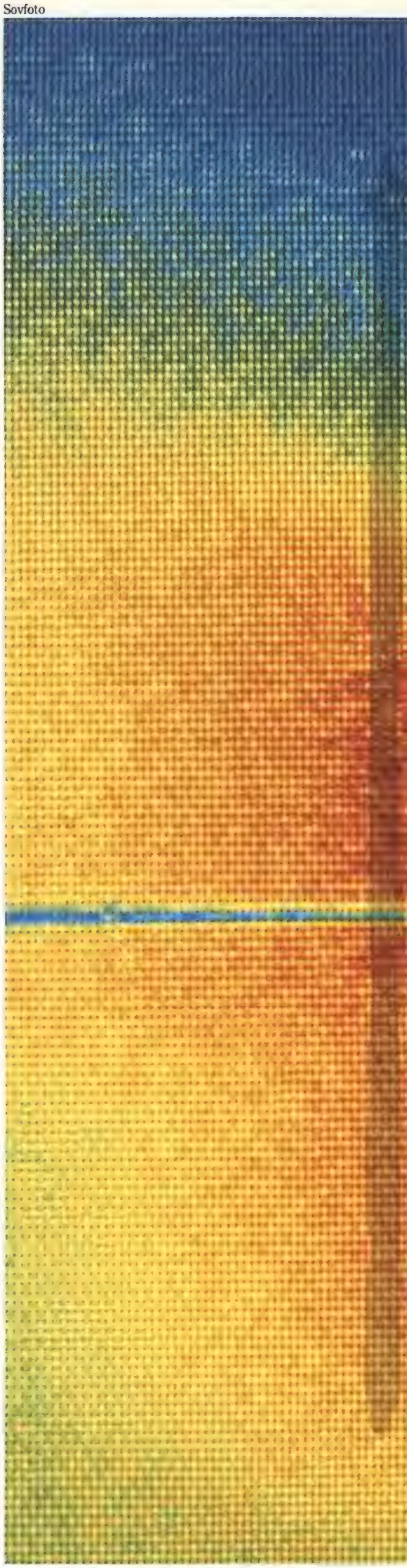
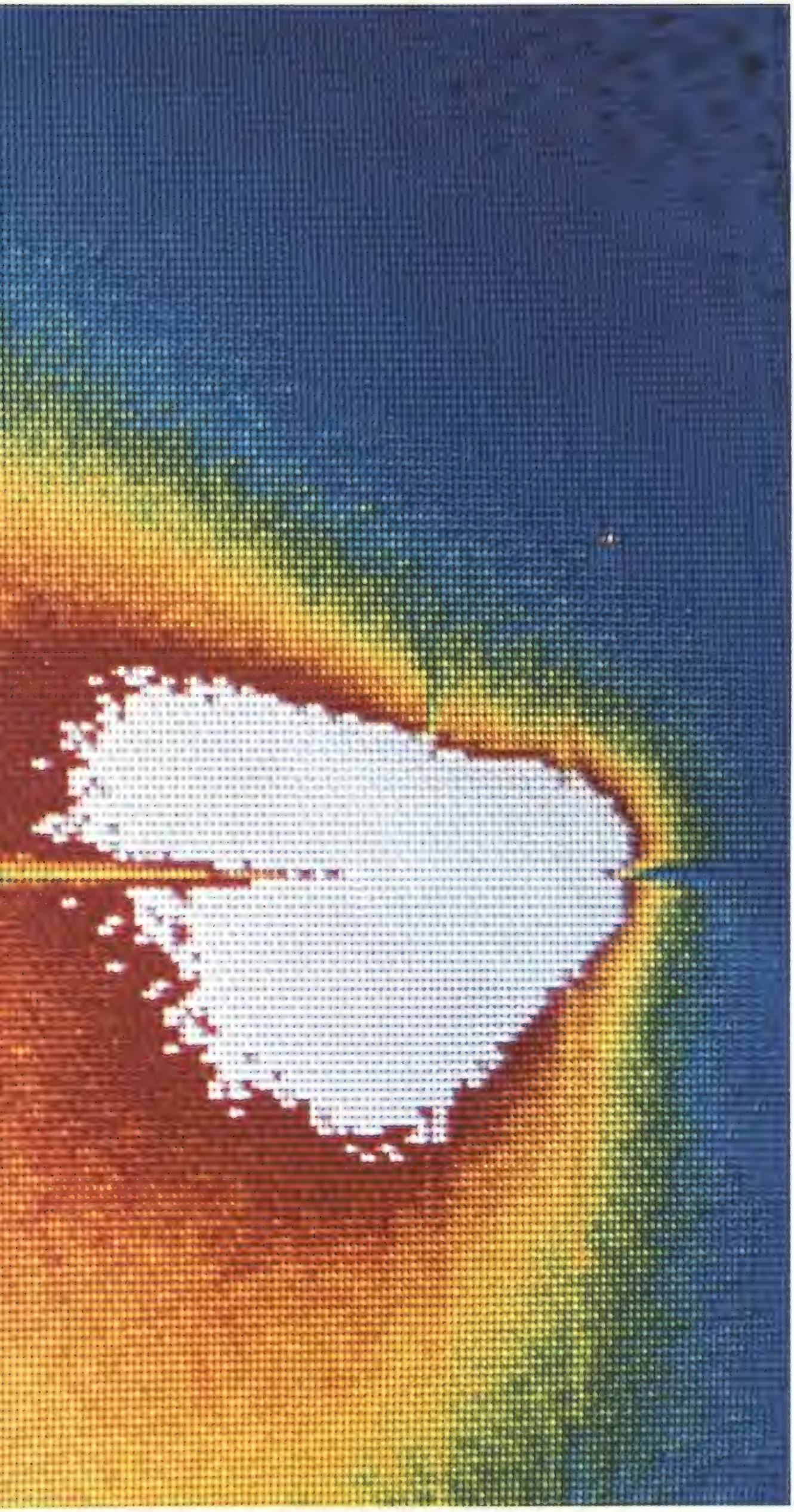




Paul Conklin

can project Pioneer Venus. Our experts on the giant planets Saturn and Jupiter have been invited more than once to the American space centers. What we regret is that there is not now any direct contact of both sides in joint projects or joint flights."

As the briefing continued, our questions strayed farther and farther from Vega. Sagdeev responded easily. When official secrecy prevented him from replying candidly, he said so without embarrassment.

What did he think of President Reagan's Star Wars system? Astronomically expensive, hardly an absolute defense, and easily countered with less expensive spoiling systems. Was the Soviet Union developing its own shuttle spacecraft? He could not go into details, but scientists were studying multiple-use vehicles, seeking more cost-effective means of getting into space. What was the role of the Soviet military in the space program? His own role? The military controlled all space launch centers, all launches, and cosmonaut training.

Roald Zinnurovich Sagdeev preaches a gospel of global teamwork in space exploration.

Clear images of Halley's Comet sent by Vega spacecraft enhanced Gorbachev's estimate of Sagdeev's talents.

Sagdeev himself directed a major research center and was a member of the State Commission on Spaceflight, an organization that certifies a craft's spaceworthiness prior to launch. Thus, he was an important administrator but not the Soviet space czar.

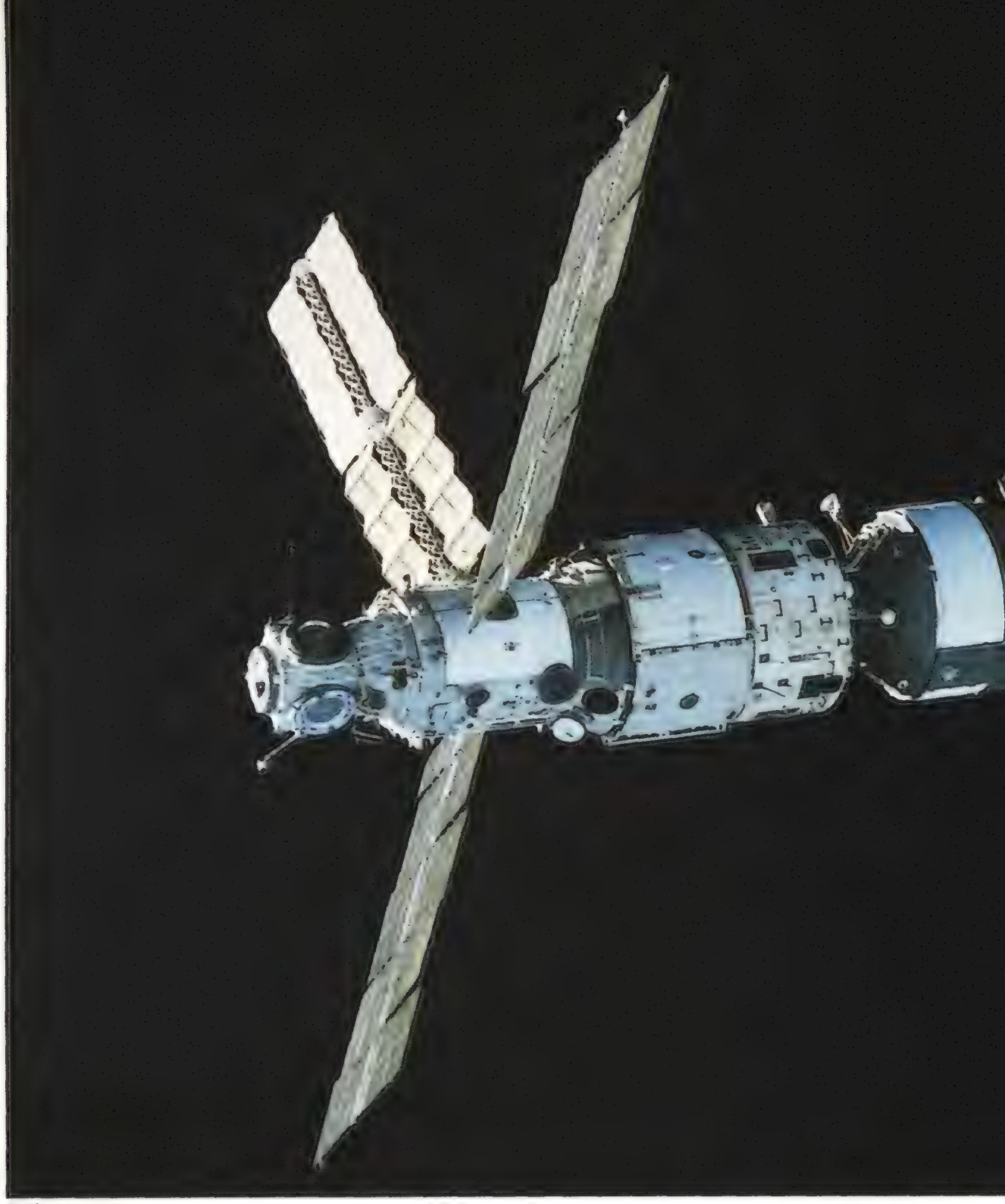
Still, he did not hesitate to tackle issues far beyond his jurisdiction. Had he been instructed to do so? I doubted it. He was displaying a breadth of vision, I thought, and perhaps betraying ambition for influence in a larger arena. IKI is only one of several institutes dedicated to civilian space research. Concentrating on unmanned exploration of nearby planets and small celestial bodies, IKI, like other specialized institutes, proposes projects to the Soviet Academy of Sciences. The academy is an elite body that controls fundamental research in the Soviet Union by deciding which proposals to fund.

Two years later, true to his parting word, Sagdeev invited me back to watch Vega 1 fly through the tail of Halley's Comet. The institute had been transformed from a highly controlled research center into an open, slightly chaotic forum. The auditorium was crowded with scientists from NASA and American universities as well as from Eastern and Western Europe. Sagdeev was everywhere, welcoming guests, resolving last-minute glitches, arranging for images of Halley to be distributed to the press. He confessed he had been up all night, worrying that a last-minute disaster would ruin years of preparations.

His efforts were rewarded. At the appointed hour on March 4, 1986, Vega 1 passed through the comet's tail near the nucleus, sending back clear color images that were captured by a ground station in the Crimea, relayed to IKI, and projected on a big screen.

There was also a personal reward. General Secretary Gorbachev summoned Sagdeev to the Kremlin and later decorated him with the Order of Lenin and proclaimed him Hero of Socialist Labor. Sagdeev's sphere of influence was expanding.

He has since been made a deputy of the Supreme Soviet (the equivalent of parliament) and chairman of the Committee of Soviet Scientists for Peace and Against the Nuclear Threat. He advises Gorbachev on space matters, particularly on how to undermine Reagan's Star Wars system with carefully crafted arguments rather than invective. He recently announced his intention to retire as head of IKI, a position he has held for 15 years. Sagdeev has been saying for some time, to me and others, that he would like to return to pure science, but his retirement could also put him in a better position to affect areas beyond the space institute. He has spoken out against "ill-conceived government policies" that are suffocating Soviet scientific research, and his call for reform includes increasing mobility in the scientific establishment—as well as shorter



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Another cooperative coup, the Mir-Kvant-Soyuz complex flies European as well as Soviet instruments.

Vega director Vyacheslav Kovtunenko and Sagdeev (center) explain comet chasing to a Soviet newscaster.

tenures for the heads of institutes.

Experts in Moscow believe that he will remain a major player in any Mars mission and will continue to work on arms control issues and Soviet-American relations. "It is hard to see how he could avoid it," says Princeton professor Frank von Hippel, Sagdeev's colleague on the newly formed International Foundation for the Survival and Development of Humanity, a group that recommends cooperative solutions to global problems. "I know that he still has a strong interest in opening up the Soviet Union." In the United States, Sagdeev has impressed both liberals and moderates with his reasonable and now-familiar message of cooperation.

But Sagdeev has critics as well, especially among émigrés in the United States who knew him in Moscow. To them, Sagdeev is not the engaging, open, dynamic interlocutor his American friends see. He is something far more sinister: a skilled operator determined to reform his nation's scientific base by skimming advanced technology abroad.

So who is the real Roald Zinnurovich Sagdeev?

His biography is the story of a gifted nuclear physicist whose career has combined political skill and international diplomacy with science. He was born in Moscow on December 26, 1932, the son of a Tartar math teacher. At Moscow University, which he entered before Stalin died, he earned both a degree in plasma physics and the confidence of authorities: his first appointment after graduation in 1955 was to the prestigious Kurchatov Institute on Atomic Energy, which was dedicated to classified projects. Sagdeev was put to work on nuclear fusion reactions.

He advanced quickly. When he was only 31 he was elected a corresponding member of the Academy of Sciences. But his rise has required him to operate in a political milieu that has its own imperatives. His detractors, noting how he has heeded these imperatives, call into question his motives for cooperation.

When Brezhnev ordered Soviet troops into Czechoslovakia in August 1968, Sagdeev was the director of the academy's Laboratory of Plasma Theory at Akademgorok and dean of the physics faculty at Novosibirsk University. A number of Sagdeev's subordinates at Akademgorok sent letters to the Communist Party Central Committee in Moscow protesting the invasion. Sagdeev fired them all.

He was chastised for that harsh action by Mikhail A. Leontovich, a member of the academy known for his integrity as well as his brilliant physics. I have been told that Sagdeev rushed to Moscow to appease the physicist, whom he respected. Leontovich impressed on his junior colleague that he could be a strong administrator without toadying to party leaders. The storm eventually blew over. At the end of that year Sagdeev was elected a full member of the Academy of Sciences, an honor enjoyed by only 100 scientists in the Soviet Union. The title "Academician" guarantees security and status for life.

Later, Sagdeev did not join other members of the academy who denounced dissident Academician Andrei Sakharov. According to friends, Sagdeev's refusal caused Brezhnev to pass him over when he was first proposed for the Order of Lenin.

Sagdeev's tenure at IKI, which began in 1973, has also been controversial. "At the time there were lots of problems to be resolved at IKI," Sagdeev recalls. He was determined to build up the institute, increase its influence within the military-dominated space program, and expand its foreign contacts. To do so, Sagdeev eschewed the anti-Semitic hiring policies of most Soviet administrators and recruited the best and the brightest, regardless of their religion.

But employing Jewish scientists carried some risks between 1974 and 1979, when Jewish emigration was increasing. Sagdeev and his deputies made it clear that they would work to prevent anyone employed by the institute, or even associated with it indirectly, from leaving the Soviet Union.

"My case was a litmus test," says one former Soviet scientist who believes Sagdeev obstructed his eventually successful attempts to emigrate. "If Sagdeev permitted me to leave easily, others would have applied. He couldn't allow that."

Sagdeev is still maneuvering politically. He led a revolt at the 19th Party Conference in Moscow at the end of June, when he corralled about 200 delegates to vote against Gorbachev's proposal that the local party boss also chair the local government council. He could have been promoting views that Gorbachev secretly holds but chooses not to voice publicly, or he could have been offering a genuine challenge. I asked Marshall Goldman of the Russian Research Center at Harvard what this meant for Sagdeev's future. "Sagdeev is the sort of man Gorbachev cannot do without," he replied. "He has skills and abilities Gorbachev needs."

Certainly he is skillful at *glasnost.* When I watched him charm the audience at the People's Summit of 1987 in

Chautauqua, New York, with a spirited chorus of "When the Saints Go Marching In" and when I saw him later laughing among a group of American scientists, speaking perfect conversational English and wearing a tie embroidered with "2001," I was reminded of his power to inspire trust. Karl Harr, National Security Coordinator for President Eisenhower and self-described Cold Warrior, has called him "intellectually honest and fearless." Says Harr, "This guy is pure gold."

American scientists who endorse Sagdeev's efforts emphasize mutual benefit. "Sagdeev's invitation gave us access to space after the *Challenger* disaster," says John Simpson of the University of Chicago, who contributed an experiment to Vega for measuring dust particles. "We had no national mission of our own to explore Halley's Comet. By cooperating with the Soviets, we came back with the first measurements. Furthermore, since each side paid its own expenses, Sagdeev got the results of our contribution for free."

Sagdeev knows that exchange with the West will have to benefit both sides. Gone are the days, he says, when the Soviet Union could send delegations abroad with the admonition "Give a kopek but get a ruble." He is currently trying to demonstrate the mutual good of his most ambitious project yet: joint exploration of Mars by the Soviet Union and the United States. As if to underline Soviet seriousness, Moscow launched two orbiters to the Martian moon Phobos in July to make a laser-assisted analysis of the soil.

Sagdeev's proposal calls for landing automated rovers on Mars by 1994 and bringing back soil samples by 1998. Total costs of such unmanned probes, he estimates, would be about $6 billion. To incite enthusiasm for the proposal, Sagdeev occasionally dangles the possibility of the United States and the Soviet Union sending men to Mars. But he is not serious about a manned mission. "It is not for this century," he told me in 1983. He notes it would cost at least $50 billion, a sum neither superpower can likely afford.

"We have the technology already for unmanned exploration with our moon rover," he says. "Incidentally, we used the rover on the roof of the Chernobyl nuclear plant and found it worked well in that hostile environment."

The Mars rover proposal alarms some U.S. officials and émigré critics, who see it as a faintly disguised ploy for technology skimming, if not downright espionage. To navigate successfully on the Martian surface, the rover would need artificial intelligence provided by NASA. But artificial intelligence is classified research, part of Pentagon projects for an automated tank and a "pilot's assistant" for a fighter jet.

Nicholas Daniloff

Since the author's 1983 visit, Sagdeev has repeatedly opened IKI to foreign scientists and reporters.

Sagdeev has proposed safeguards—tamper-proof "black boxes"—to protect secret U.S. technology needed for guiding the Mars rovers. But worries remain and are compounded by disturbing reports that IKI has secretly obtained a CRAY supercomputer and Digital VAXes, equipment whose export to the Soviet Union is prohibited by the United States.

Sagdeev has acknowledged that IKI possesses some equipment on the prohibited strategic items list, but denies it was illegally obtained. "When you, in the United States, declare an embargo," he said, "you automatically create a black market." Enterprising European middlemen supplied IKI with the restricted technology. Sagdeev said that no Soviet laws had been broken and that his job did not include enforcing U.S. regulations.

He will admit to ulterior motives for the Mars mission, however. "Arms reductions are not enough for stable Soviet-American relations," he told me at an earth resources conference at the University of New Hampshire last spring. "Our two countries ought to have a long-term vested interest in common."

And he has made it clear that open exchange is one hope for reviving his country's scientific establishment from its bureaucratic stupor. In a stirring attack in the newspaper *Izvestia* and more recently in the American journal *Issues in Science and Technology,* Sagdeev flogged the Soviet scientific community for complacency, inefficiency, and unnecessary secretiveness.

But behind him, Soviet intelligence agencies—the KGB and its military counterpart, the GRU—are also pressing hard for institute directors and scientists to obtain, by stealth if necessary, ideas, systems, and equipment to overcome the obvious technological lead held by the West. The Soviet government's Military-Industrial Commission has targeted nearly 4,000 areas of Western technology in which acquisitions are urgently sought. Every Soviet institution feels the heat through its liaison with the KGB and its "First Department," which handles security, classification, and intelligence.

Consequently, the U.S. government will have to make a judicious calculation with the help of its leading scientists. What can the United States expect to get from cooperation with the Soviet Union? What can it reasonably share? What secrets must it protect at all costs? The answers will apply not only to joint space exploration but to all areas of scientific cooperation.

Because of the differences between American scientists, who generally want collaboration, and the guardians of U.S. national security, reaching a consensus at home, and then with Moscow, may be almost as difficult as the journey to the Red Planet—despite charmers like Sagdeev. ✦

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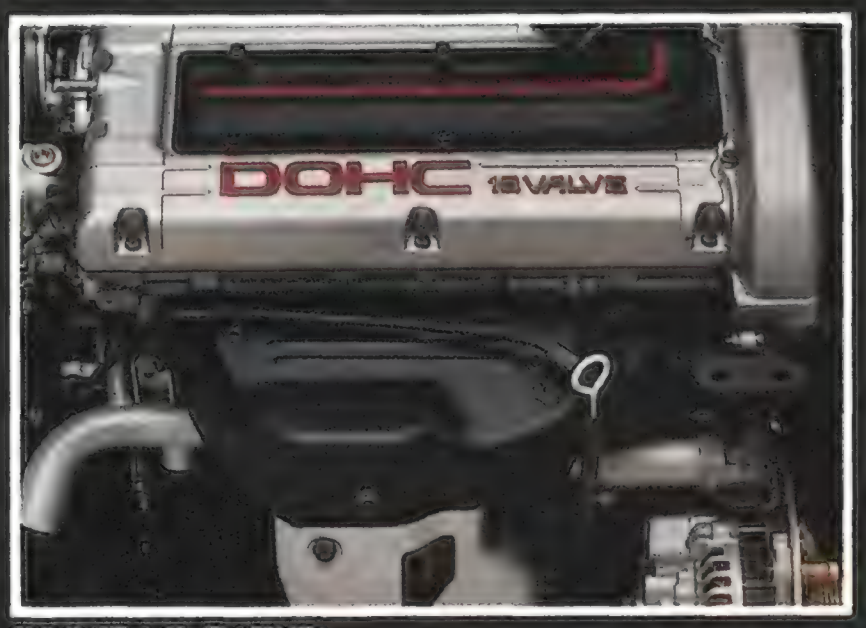

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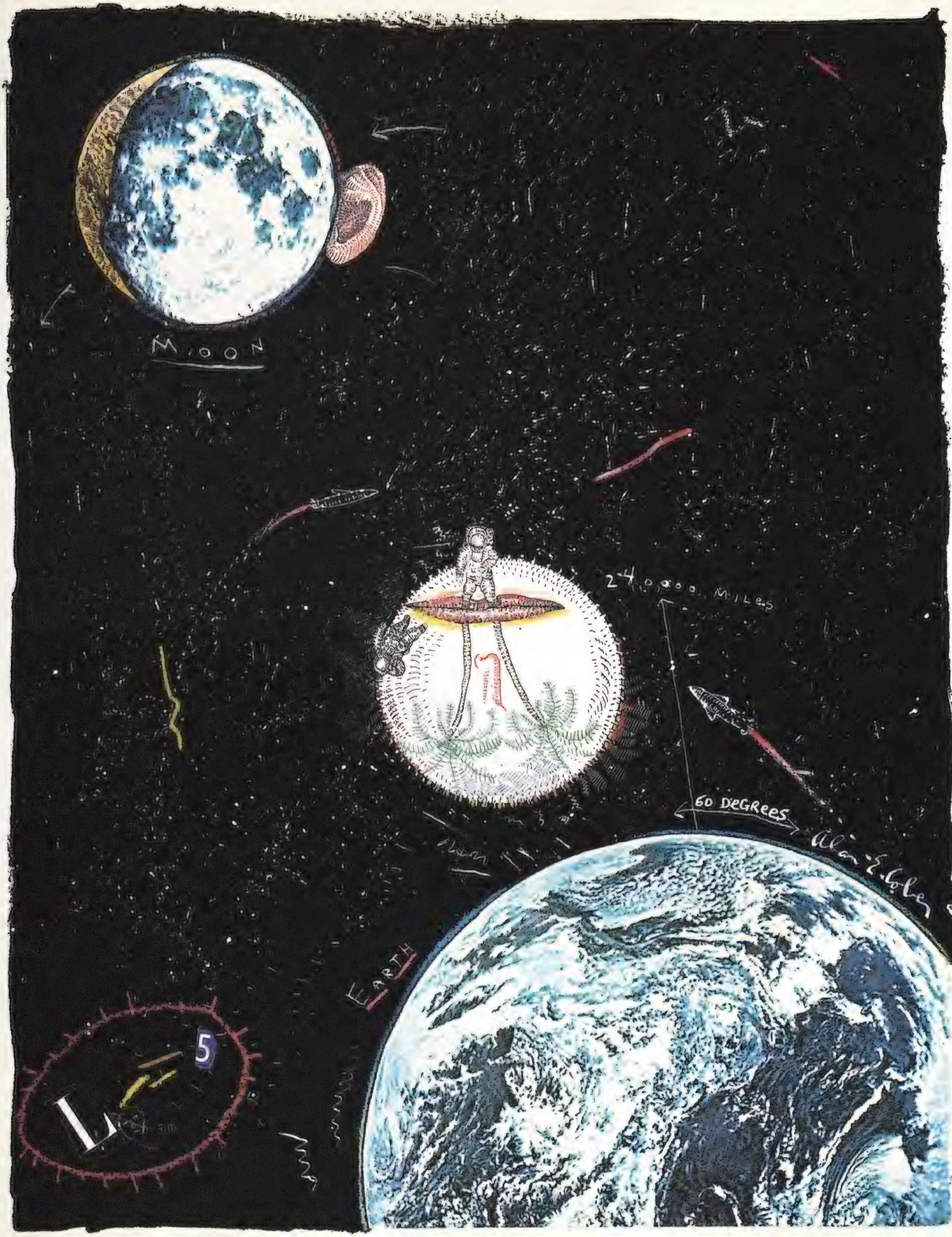
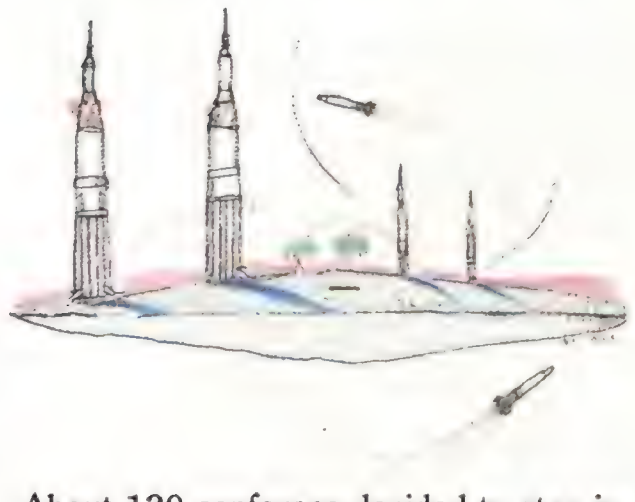

MOON
240,000 MILES
60 DEGREES
EARTH
L5
5

HIGH SOCIETY

Where do you go when the Earth is no longer enough?

by Doug Stewart

Illustrations by Alan E. Cober



Not long ago Dave Hannah had an idea: he wanted to buy surplus Minuteman missiles from the U.S. government. A retired archeologist living in Colorado Springs, Hannah (no relation to the Texas oilman/space entrepreneur of the same name) was a gung-ho member of the L-5 Society, a space advocacy group. To Hannah, acquiring a fleet of refurbished ICBMs seemed like a nifty way to give fellow members some hands-on experience in space research. "I figured we could buy the missiles at scrap rate," he says. "The missiles were already sitting in their silos. We'd take out the warheads, which are quite heavy, and replace them with payloads."

Hannah didn't plan to put any astronauts aboard; he just wanted to get a private space launch business started. "L-5 would have become the third strongest space power on earth," he says, grinning.

"They"—by which Hannah means NASA, the Air Force, and L-5's leadership—found the scheme a bit too exotic. Nonetheless, the idea exemplifies how the full-speed-ahead space activism of the L-5 Society's members differed from the wistful fantasizing of the average science fiction fan.

The group grew out of a 1975 space manufacturing conference at Princeton. About 130 conferees decided to stay in touch via newsletter, and within a couple of years, thanks largely to publicity generated by science fiction writers such as the late Robert Heinlein, a loosely joined assortment of local chapters had sprung up across the country. Most members were personally intent on heading into space, and the society's stated goal was to "get tens of thousands of people living and working in space as soon as possible."

The name "L-5" referred to the site where the society planned to hold its final meeting, the Lagrange libration point number five. Libration points are points in space surrounding planet-moon systems. If a third very small orbiting body is located at a libration point, it exists in a state of balance in which the force tending to fling it out of orbit (sometimes called centrifugal force) is exactly countered by the combined gravitational pull of the planet and its moon. A body at the Earth-moon L-5, located an average of 240,000 miles from Earth and 60 degrees behind the moon, would remain in a stable orbit for years and thus would be the perfect site for the space society's final meeting. Once that milestone had been reached the society would disband, mission accomplished—the members perhaps immediately reconvening as the Interstellar Society.

Last year L-5 merged with another space advocacy group, the National Space Institute, to form the National Space Society. The NSI was a highly centralized, politically savvy outfit founded by Wernher von Braun in 1974 as a Washington-based lobbying effort. It had strong ties to the aerospace establishment, and its ideas about space exploration tended to parallel NASA's. The L-5/NSI merger was motivated more by the instinct for survival than by any genuine attraction between the two groups: the L-5 Society was losing members, particularly in the aftermath of the *Challenger* accident, while the NSI had never succeeded in attracting grass roots support.

The NSS's charter—to encourage "the creation of a space-faring civilization which will establish communities beyond earth"—encompasses the goals of both organizations. (The meeting at L-5, which was never part of the society's formal charter, has been quietly shelved.) Written statements, though, can't paper over the differences in style and priorities between former L-5 and

NSI members. The L-5 Society was well stocked with rugged (and sometimes rough-edged) individualists who weren't at all enthusiastic about joining forces with the NSI's more buttoned-down crowd. "You don't want to quote what I have to say about the NSI types," says dyed-in-the-wool L-5er Hannah. But according to Jill Steele, who also came to NSS via L-5, "it's all sort of blending together."

The NSS's 20,000 dues-paying members include astronauts, aerospace executives, military brass, schoolteachers, college students, science fiction writers, and assorted space buffs. They live all over the United States, with a few scattered in other countries, and are organized into approximately 100 chapters. The chapters—which still consist largely of former L-5 members—sponsor lectures and debates about space development, set up slide shows in shopping malls, and bombard their Congressmen with pleas for more space spending. From its Washington headquarters, the group's leadership fights for goodies like space stations and planetary missions, and battles threats such as legislation that would squelch capitalist ventures in space—mining the moon, for example.

Dave Hannah is 59 years old, but he hasn't given up on the idea of moving off-planet. "The adventure side of space has a maddening appeal to me," he says. Hannah is obsessed with the idea that Earth has become too crowded. His Colorado Springs apartment sits literally in the shadow of Pikes Peak's 14,100-foot summit. "They've got a road to the top now," he says. "Also a hiking trail, a railroad, and, for part of the way, an incline railway." He shrugs. Buying a ticket to the top isn't Hannah's idea of adventure. Living in a space colony is. "There'd be a superb view from there," he points out. "You could see the entire universe. And not just on a clear day." He pauses for effect. "You could *always* see the entire universe."

A nonstop talker with a bushy goatee and a taste for Western-style shirts, Hannah is the founder and president of Pikes Peak L-5, the NSS chapter in Colorado Springs. The chapter, started in 1984, consists of 85 dues-paying members and meets on the second Saturday of every month. Hannah claims to spend more than 80 hours a week on space boosterism. With the practiced diction of a college lecturer and the zeal of an evangelical minister, he preaches the virtues of living in space to any civic group or elementary school class that will have him.

"There is a school of thought that every human being on Earth should be well fed, well clothed, well housed, and have good medical care before funds are expended for any other purpose," he says. "If the Europeans had waited until every shoestring were tied, we wouldn't be here today." Hannah, who refers to Alexander the Great as "Alex the Great," clearly has no difficulty with the concept of terrestrial conquest on a grand scale.

NSS stalwarts like Hannah see business as the catalyst for humanity's inevitable migration into space. They believe space pioneering should be a commercial venture, pointing out that 16th century expeditions to the New World were justified by the codfish that could be brought back to Europe; the early explorers had no idea what was to follow. The same may hold true for space: the vacuum, the temperatures, and the weightlessness may allow industries no one has yet imagined.

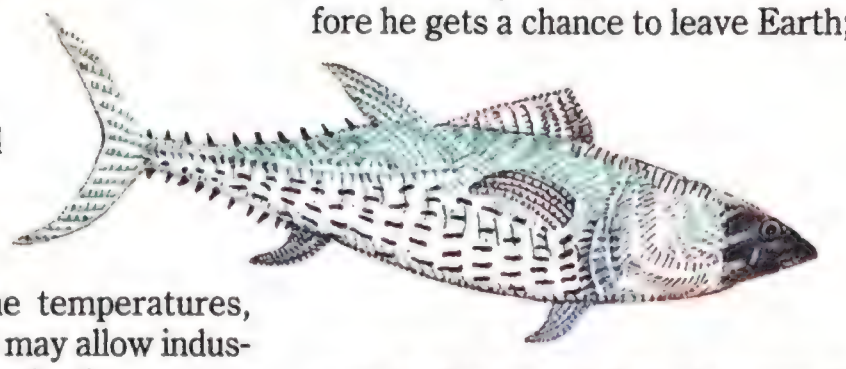
Hannah envisions dozens of huge solar-powered satellites beaming energy back to Earth; mining operations on the moon and the asteroids to scrape together the raw materials to build space structures; and crystal-growing and alloy-mixing in weightless, automated labs. The first colonies would be orbiting habitats for the construction and maintenance crews. Later colonies would be huge, self-sustaining cities. NASA, in this scheme of things, would no longer run the show. "The first trillionaire is going to come from space," Hannah says. "*If* the bureaucrats don't stop him."

NSS members have little love for the meddling of big government—most are staunch conservatives. For many, the most alluring aspect of space is the promise of living beyond Earthly limits, both natural and man-made. Space colonists could make their own rules. At an impromptu gathering of the Pikes Peak chapter, a half-dozen true believers discussed just what those rules might be.

"You'd control the climate and the seasons," said Keith Hamburger, a cheerful and extremely fast-talking young teacher. "It would rain when you wanted it to rain. And there'd be no mosquitos—unless, of course, you wanted mosquitos."

Social organization would also be a matter of choice. "If the Iranians wanted their own space colony, they could run it by the laws of Allah," said Mark Grisko, a real estate broker, steam locomotive salesman, and the group's token Democrat. "It would be completely different from, say, a libertarian space colony." Nudist colonies, the members agreed, would also be a definite possibility.

The Pikes Peakers are doing more than just fantasizing about living in space. Jerry Emanuelson, a soft-spoken electronics engineer, is signing up to have his body frozen in case he dies before he gets a chance to leave Earth; if a cure is discovered for whatever killed him, he'd be thawed, healed, and sent aloft, ready for action.



Doug Jones, a 25-year-old with a


GREAT VIEWS
SUSHI BAR
20 miles
Alloy-mixing...
4 miles
crystal-growing
COAL
MOON
alan E. Cober

fondness for computers and skydiving, heads one of Pikes Peak L-5's spinoff corporations, Hummingbird Launch Systems, which is working on an eight-foot reusable sounding rocket that will carry a payload of 30 to 50 pounds on a suborbital three-minute trajectory. If the prototype lives up to expectations, Hummingbird hopes to sell the rockets for $100,000 apiece.

In his younger days, Jones launched homemade hydrogen balloons trailing long fuses: do-it-yourself exploding UFOs. While in the hospital recovering from a launch mishap, Jones first read the closest thing L-5 had to holy scripture: Gerard K. O'Neill's *The High Frontier.*

In the book, O'Neill, a Princeton physicist, describes a large-scale, technically feasible space habitat in detail. In 50 to 100 years, he writes, humans could live and work inside sealed cylinders 20 miles long and four miles in diameter. Each tube would slowly spin like a barber's pole to provide artificial gravity for the inhabitants. Eventually, as many as 10 million people could live in comfort along the inside surface of each tube.

Would-be colonists argue that the technology needed to build such abodes isn't particularly exotic. Without gravity constantly tugging at them, the orbiting tubes, constructed of moonrock concrete, could be enormous and extremely lightweight.

NSS members concede that a city-sized O'Neill cylinder is a best-case scenario. The first permanent habitat in space will more likely be a cross between an offshore oil rig and the interior of a World War II-vintage submarine. According to author Robert Heinlein, the first wave of space colonists will probably resemble the pioneers of the Wild West: "The born losers would not make the effort," he wrote, "the cowards never started, and the weaklings died along the way."

While a macho minority within the NSS may welcome space migration as the ultimate no-holds-barred land rush, most members imagine space colonies as friendly, humanistic utopias. "In the Old West, there were a lot of rugged individuals going out on their own," says Jill Steele, vice president of Denver's mushrooming NSS chapter. "To go into space will take a lot more cooperation. An individual can't just pack up a mule and wander off.

"We all see the importance of getting off Earth," Steele says. "We'll stay up all night and talk about anything from politics to evolution to war in space to sex in zero G." (Neil Dutcher, a 33-year-old comic book artist, has mulled over the pros and cons of sex without gravity and has concluded that Velcro would make things easier—"but black-lace Velcro," he adds.)

Steele, 30, works as an industrial engineer for an aerospace firm. At night, when she's not planning or attending space-related events, the tall, athletic blonde sometimes works as a belly dancer. "The chapter is like a second family to me," she says. "I go to work in my spare time."

Steele jokes that she hopes to open the first sushi bar in space. She has enough fantasies about life aloft that she calls this one her favorite: "A woman, possibly wearing a loincloth, is walking through a jungle, picking fruit off the trees," she says. "There are no poisonous insects or anything—it's a human-friendly jungle. Then she'd walk into a cave and a door opens. She steps through the door, showers, changes into a spacesuit, and walks through the space station back to the control room. This has been her lunch hour, you see, and she's coming back from her break."

A skeptic might wonder who's going to pay for all this scenery, but Steele points out that the whole idea of large colonies in space presupposes a flourishing and profitable trade with the mother planet. "If 200 years ago people saw a picture of Disneyland or the streets of San Francisco," she says, "they'd have said the same thing: 'Who's going to pay for all that?' "

Fellow Denver chapter member Dutcher has come to realize that normal people—people who flunked math and can't do pushups—have a right to go into space, too. "I grew up with the idea that all astronauts were a cross between Captain America and some mad scientist, people with huge brains and amazing reflexes," he says. "We're not talking about sending up 20 scientists. We're talking about sending 20,000 people up there, and they can't all be scientists. They're going to need people like me."

Dutcher, an animated extrovert, turned to space activism after becoming disenchanted with the environmental movement of the 1970s. "People kept saying that technology was bad and that we were running out of room and running out of resources," he recalls. "Then L-5 comes along and says that just the opposite is true, that the universe is chock-full of everything we want. All we have to do is go out and take it." Dutcher found that outlook far more appealing. "We're talking about new land! Not previously owned by anybody! No environment to destroy, because there isn't anything living there until you put it there."

Dutcher admits he's a utopian, but he doesn't expect that in space people will live together happily ever after. "I figure that every [group] ought to build their own little island in the sky," he says. If disputes arise that threaten a colony's welfare, he suggests, the splinter group can simply rocket off to build its own colony.

"The American dream is in danger of stagnating any time we sit still," Dutcher says. "I think we can build real paradises in our solar system—places where people can become whatever it is they want to become." That, to Dutcher and the other members of the National Space Society, is the dream underlying their talk of spaceships, off-world colonies, and sushi bars. The organization "isn't about space," says Dutcher. "It's about people." ✈

Alexander the Great

THE EARTH IS TOO CROWDED

I MADE IT! SUMMIT OF PIKES PEAK COLO. ALT. 14,100 FT.

NO ADVENTURE HERE

DAVE HANNAH

Alan E. Cober


Concourse E
Ticketing
Terminal 4
B8

UNITED'S CRYSTAL PALACE

Architect Helmut Jahn has created a 21st century air terminal at O'Hare.

by Frank Getlein

Photographs by Mark S. Wexler

The Bettmann Archive

The Terminal for Tomorrow's antecedents include the Eiffel Tower's exposed metalwork, which prompted Parisians' disapproval.

In 1851 another inspirational public structure, the Crystal Palace in London, boasted a vaulted roof (left).

The Bettmann Archive

In pre-Madison Square Garden days, New York's Penn Station was filled with light and air. Then, as now, it was filled with commuters as well (right).

The United terminal's design looks to the past but also, appropriately, to the sky.

The Bettmann Archive

It was mid-December '87 and I was in Chicago, scheduled to leave for Kansas City. The television showed enhanced satellite photos of heavy snow closing in on both cities. Studying the animated maps closely, I concluded that I could certainly get out of Chicago before the snow got in and quite probably get to Kansas City before it got serious there. Worth the gamble. I took the subway to O'Hare, raced through the procedures, and arrived at the gate to find a not unexpected delay.

The enforced relaxation gave me a chance to make a completely unexpected discovery. Looking around, I found myself in an air terminal full of light and space—full of grace, for that matter—glass walls curving into glass ceilings, the structural components as visible and as ordered as those of Chartres or the Eiffel Tower, the whole imparting feelings of buoyancy and elation.

At that point in my reflective exploration, my K.C. bet paid off and off I went.

When spring broke through again, however, so did I, this time spending four days in what is easily the most architecturally important city in the country. Most of those waking hours I was out at what United Airlines calls its "Terminal for Tomorrow," gaping and gawking and talking to workers and fellow travelers.

I found my original impressions powerfully fortified and on the whole shared by the people I talked to. Some were more enthusiastic than others, but all were aware that we were in a very unusual building, "almost," said one, "a kind of cathedral of flight."

The comparison is neither as odd nor as blasphemous as it may seem. When the great railroad terminals were built in the early decades of this century, they were commonly referred to as "the cathedrals of the 20th century," meaning they were the largest architectural projects that satisfied something

Helmut Jahn is no stranger to controversy. The German-born architect has detractors as well as champions.

Gwendolen Cates

besides the need to multiply work and living space. There may also have been a hidden meaning about America's alleged worship of speed. And there was a meaning not hidden at all: Welcome to our town, isn't it the berries? Washington's Union Station as it used to be—passengers would walk through the ornate waiting room and then come out on the arcade facing the north side of the United States Capitol—was the nicest statement anyone ever made about Congress.

It follows that airport terminal buildings ought to be the cathedrals of the late 20th century—but are they? Need you ask? A couple of them do live in memory: Yamasaki's at St. Louis before it got a wraparound expansion, and Eero Saarinen's Dulles International in Northern Virginia, which speaks more directly of flight than any other terminal has until now. The rest . . . eminently forgettable.

But now, the Terminal for Tomorrow is just what its name says it is. In its engineering, and even more emphatically in its architecture, it reaches for the future.

United planned the terminal with the purpose of "making a statement in Chicago," says the terminal's superintendent of maintenance, Richard Cloud. O'Hare had become a byword among frequent fliers for terminal misery. Chicago is United's headquarters city—and its busiest hub—so the airline wanted the statement to be powerful and positive.

The way you make an architectural statement in Chicago these days is to hire Helmut Jahn. The German import is the hottest architect of the moment in a city where that title has been held by Louis Sullivan, Daniel Burnham, Frank Lloyd Wright, and Mies van der Rohe. In and around the Loop, Jahn has established himself as a peer of those predecessors with work that is not postmodern but late modern, proving that you can turn back the clock if it's going too fast, and that there's life in good old modern yet if you know where to look. Jahn clearly does.

Of course, not everyone likes where Jahn's looking. Modern in his hands is often shocking, and responses to his buildings are emotional and polarized. The controversy over Jahn's State of Illinois Center, dubbed "Starship Chicago" by natives, was national news in 1985. "Tinselly and decadent," complained architect Harry Weese in *Time*. Jahn has been accused of ignoring context so that his own creations overpower their neighbors. He has been called a rule-breaker and a prima donna. One angry observer of the Chicago architectural scene called him a "Kraut son of a bitch," but he is of the generation instructed by the U.S. government that that phrase is a single word. In a *Chicago* magazine profile, Jahn calls himself a businessman, and at the Terminal for Tomorrow, business is good.

The terminal's shell is curved glass roofs, stepping down in layers from each concourse to the tarmac level. From an architectural-historical point of view, those curves rescue Bauhaus purity from the cheapening effects of places like Washington's K Street and New York's Sixth Avenue, where developers interpreted the "less is more" doctrine to mean give the customer less and charge more.

The structure's exposed beams and trusses link the building to the granddaddy of all glass buildings, the Crystal Palace in London, and especially to the supreme achievement of the

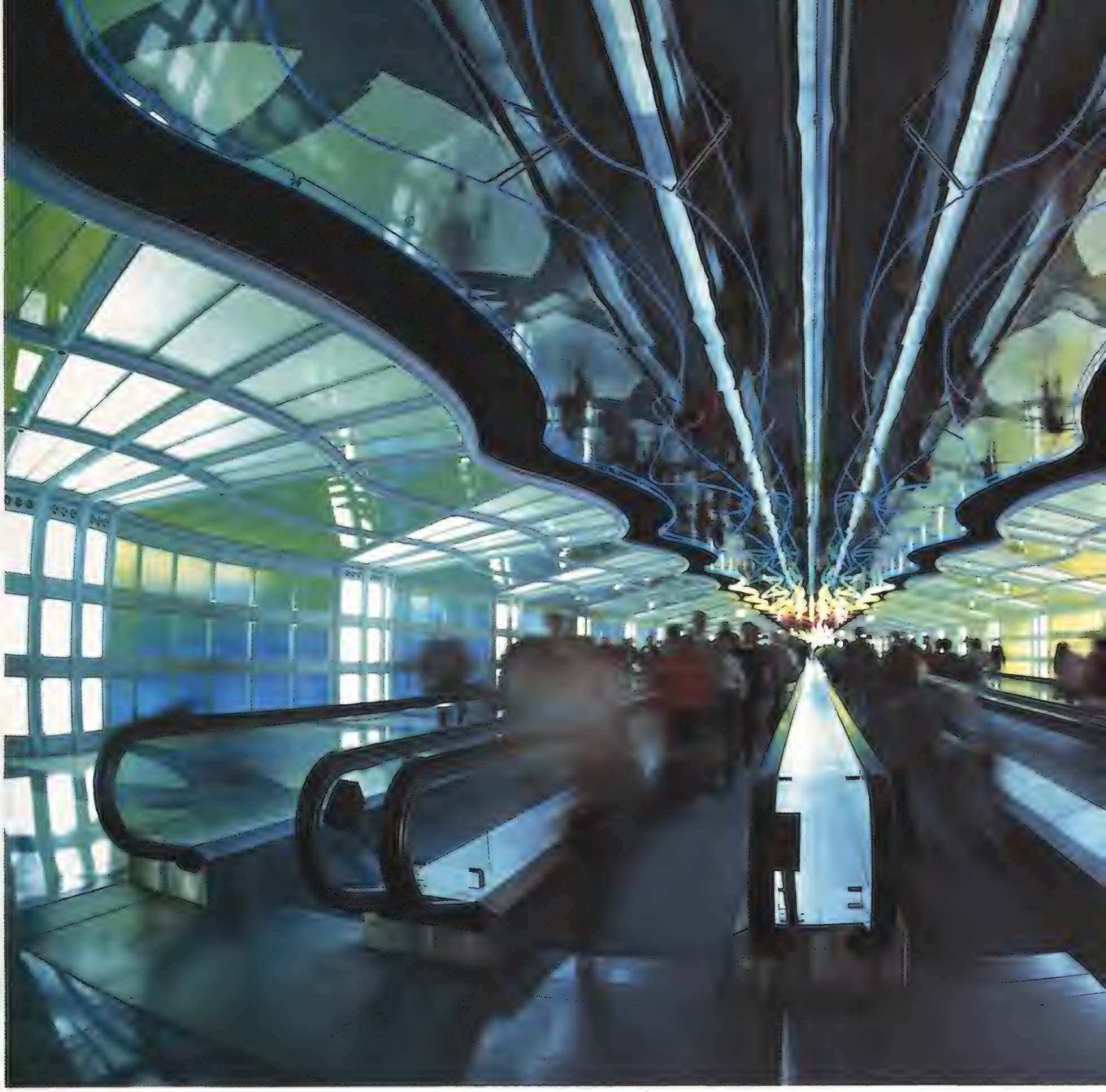
railroad cathedral builders, New York's Pennsylvania Station. The beauty of that structure, before it fell to corporate vandalism, was double. There was the vast main waiting room, derived by Charles McKim from the Roman Baths of Caracalla. And there was the scarcely less vast train shed and concourse, pure 20th century—as in the train of the same name—all glass ceilings to let in the light of day, and structural steel of elaborate and rhythmic design. The United terminal obviously recalls McKim's train shed, but in those curving roofs there is also at least a whisper of Caracalla's ceilings.

The floor pattern may be from Michelangelo, but the ceilings are more pristine than Sistine (left).

The terminal isn't just a work of art: its business is business. United expects it to serve 80 million passengers a year by 1995.

The innovation that strikes most people first is not the architecture but the engineering. Indeed, engineering was the area in which United made its most stringent demands. All the terminal's systems, and the engineering that makes them possible, were the givens, the things to be contained that Jahn made the container for. Mediating between architect and engineering was Allen L. Pomerance, vice president of A. Epstein and Sons, Inc., the architects and engineers of record for the terminal construction project. Jahn was responsible for conceptualizing the terminal; Pomerance had to transform the concept into a workable structure that would conform to United's requirements.

Ideally, a passenger's course from curbside to aircraft is a straight line. In the United terminal, the curb, the counters, and the two concourses are all parallel, so a direct, perpendicular path is possible. United calls this geometry "flow-through." The traveler leaves his bags at one of 56 check-in counters and flows through the counter, through security,



Tunnel vision paid off as the way to bridge the gap between concourses.

into the concourse, and on to his gate.

The bags, meanwhile, have descended from behind the counter into the most sophisticated baggage handling system ever. The baggage tags are read by laser and the luggage is sorted and routed along a series of moving belts, slides, and laser-activated steering paddles. The system handles over 400 pieces per minute and it had better: since the terminal opened last year, passengers have flowed through at close to 50,000 a day. Every one of them, statistics say, carries 1.9 bags.

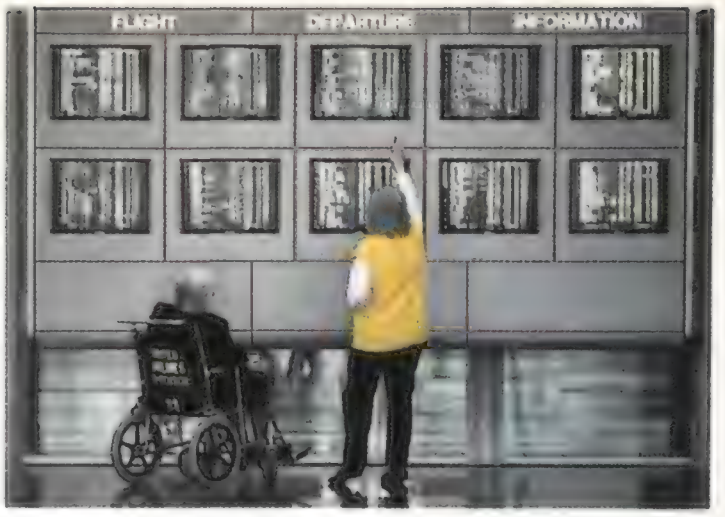
You don't see it or even think about it, but spare parts for airplanes have a system equivalent to flow-through check-in and belt-driven baggage routing. Any mechanic at any gate can punch up what he needs on a computer and it will be delivered in minutes through a network of pneumatic tubes descended from the system of little capsules that used to carry money and receipts around department stores.

Likewise unnoted by most passengers but contributing to their ease is the fact that the spread between the terminal's two concourses is wide enough to allow two 747s to pass each other.

That spread, of course, must somehow be bridged for passengers, since you check in at the same place for either concourse. This bridge is a tunnel. But what a tunnel! The trouble with most airport tunnels is that you get claustrophobic and feel that the aerial voyage you have embarked on will never get

up on, let alone off, the ground.

At the United terminal, Jahn has changed all that. The walls are a series of sine curves—you can look it up in an old trig text, but it's roughly the equal and opposite curves that Thomas Jefferson made in brick for his University of Virginia to let the students know that a straight line is not necessarily the shortest distance between two points. These undulating walls are clad in transparent plastic behind which colored light glows in soft tints. Overhead, light sculptor Michael Hayden has created the only neon work I've seen that equals the displays at Times Square. Tubes of light ray out in jagged bursts from a central ring halfway between the two concourses, dazzling red in the middle, stepping through



Nobody wants to miss a flight, and airport visitors can keep track of comings and goings at a number of locations.

But when you do have to wait, it's easy to find a phone.

United claims that employee morale is higher here than it was at its previous O'Hare terminal.

the spectrum and down to white at the two ends. The lights' timed switches create a ripple effect as you ride beneath on moving sidewalks.

The effect of all this is: no tunnel. Originally, Jahn commissioned what would have been high-tech Muzak—a composition by William Kraft—to play along as the passengers rode along. In response to popular demand, United abandoned its Kraft and put in a pastiche of the high points of George Gershwin's "Rhapsody in Blue." The change can be easily criticized as caving in to bourgeois taste, but the fact is that good neon is much closer to Gershwin than to any music being written today. The sound and light now go together like George and Ira. And it's hardly a coincidence that the tunnel's new audio element echoes the Rhapsodic reprise United uses in its current commercials.

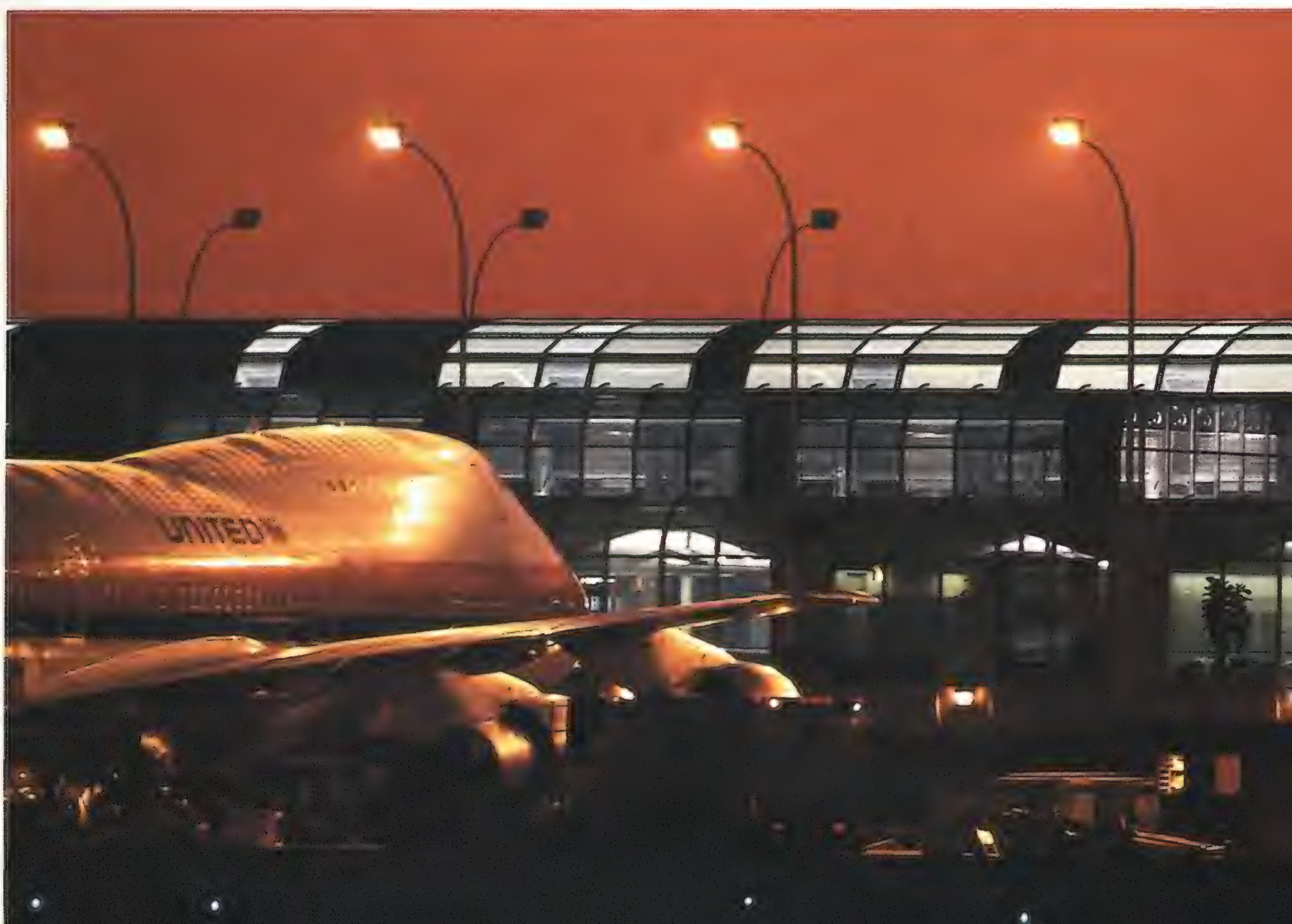
The treatment of that subterranean passage has made what could have been the weakest point in the whole ensemble into one of the strongest—precisely what the flying buttress, put in to hold up perilously weakened walls, did for the Gothic cathedral.

The terminal succeeds on the minor-amenities level, too. Information, which airlines historically have hoarded as a precious asset, is all over the place. Light boards provide the latest word for the ticket lines, recommending different counters for faster service; others are positioned throughout both concourses. Even the fast food features some appealing entries: orientalia, health foods, Jewish deli, *inter alia* (the *inter alia* being particularly good for the price).

The construction of this $500 million extravaganza did not always proceed smoothly. Since United demanded that the terminal be in business by Labor Day, the building opened last August before the glass on the roof was caulked. Of course, the rains came and came and kept on coming: a record-breaking 17 inches for the month, much of it seeping through the ceiling and falling on Jahn's floor. That's been fixed. I've been there in rain and snow and haven't seen a drop.

The rainforest effect instantly put Jahn in the same league as Frank Lloyd Wright. In 1936 a leaking Wright-designed roof prompted Mr. Johnson of wax wealth to call his architect and complain that rain kept falling on his desk, thus eliciting Wright's legendary reply: "Mr.

The structure's 15 acres of windows let the sun shine in—and the lights, out.



Johnson, I have one piece of advice for you. Move your desk."

There was one other grave glitch. Jahn had run the glass roof designs through a computer programmed with the sun's angles of inclination at different times of day and year to ensure against dangerous reflections into the control tower. The computer-approved glass was put in place and instantly projected dangerous reflections into the control tower, proving that computers perform for German geniuses no better than for the rest of us. This led to an adventure in quick fix. The entire roof surface glass was etched, piece by piece, to eliminate the glare. It worked.

Like millions of traveling Americans, I have long carried with me only what could be legally carried on. When I went to Chicago I took three bags and checked them all, to give the system a test. It, too, worked. By the time I got to the baggage area, all my bags were waiting.

Back home in Washington, I was at the baggage area in five minutes and the first bag showed up in 20. D.C. National is, as I'd long suspected, the Air Terminal for the Day Before Yesterday. I'll take Tomorrow.

Computers keep tabs on baggage and spare parts, among other things (above) . . .

. . . so that passengers can relax and enjoy the view—or not, as they see fit.

by Simon Baker

"The Hitherto Impossible in Photography Is Our Specialty"

The first commercial aerial photographer used everything available to get the best perspective.

At 5:13 in the morning of Wednesday, April 18, 1906, the earth beneath San Francisco began to heave. Pressures that had been accumulating along the San Andreas fault were suddenly released, and it took a full minute for the colossal forces to spend themselves. In that time many places on the west side of the rift were thrust 16 or more feet to the northwest.

The fires began immediately, caused by overturned stoves, fallen chimneys, exploding gas mains, and downed wires. Firemen responded to dozens of calls, and everywhere they went they made the same awful discovery: there was little or no pressure in the water mains. The earthquake had destroyed San Francisco's water system.

For three and a half days the fires burned out of control. Finally the authorities resorted to dynamiting streets full of buildings and pumping water from the San Francisco Bay to stop the conflagration. Amid the smoldering ruins of 522 city blocks, more than 200,000 San Franciscans were left refugees in their own city.

News of the unparalleled disaster horrified the country. In Chicago, George R. Lawrence made plans to get to San Francisco as soon as possible and make a photographic record of the devastated city. Three weeks later he was there, hard at work with his crew. It must have been terribly difficult to work amid the chaos of a shattered city, but in the end his efforts provided a remarkable series of photographs, the likes of which had never been seen before.

Photos courtesy Chicago Historical Society

A hydrogen balloon proved handy in getting George Lawrence 900 feet above the Chicago stockyards during a 1901 photographic assignment. But after a few near-fatal ballooning accidents, Lawrence decided to develop the camera-carrying potential of kites.

One of his pictures in particular caught the attention of the world. "San Francisco in Ruins" showed the entire city on a single print 48¾ inches long and 17½ inches wide. The gargantuan image was not an enlargement; it was a contact print made from a single piece of film. Even today it is difficult to imagine a camera capable of making such a photograph. But it isn't just the size of the equipment that seems astonishing: when the famous photograph was made, the camera was hanging 2,000 feet above the San Francisco Bay.

For the man whose business slogan was "The Hitherto Impossible in Photography Is Our Specialty," the making of this photograph was a routine matter. Lawrence had come a long way from his first encounter with commercial photography 16 years earlier, when he was a 23-year-old fresh off the family farm in Manteno, Illinois. In the 1890s he devised a method for synchronizing the firing of a series of flash charges and formulated a brighter flash powder. (His early flash experiments didn't always work out: one partially destroyed his hearing and blew his young son Raymond out the window). Five years later he won the Grand Prize of the World for Excellence in Photography at the Paris Exposition. The award honored Lawrence's design and construction of the world's largest camera: a 1,400-pound giant holding glass plates measuring eight by four and a half feet.

Throughout his photographic career Lawrence was driven to capture images of large scenes. His interiors included banquet groups, legislatures in session, and political conventions. Outdoors he captured the crowds and the action at baseball games, horse races, and football stadiums. He accepted commissions to photograph entire industrial plants and did so on single pieces of film, using cameras he built himself. For outdoor work camera position was crucial; sometimes two 20-foot guyed ladders provided enough height, but other subjects required greater elevation. In typical fashion, Lawrence designed the solution: a portable telescoping tower of wood and wire that enabled him to make photographs from heights approaching 200 feet.

Soon even the tower wasn't high enough. For an assignment to photo-

graph the Chicago stockyards in 1901, Lawrence modified a hydrogen balloon by removing the basket and replacing it with a wooden platform for himself and his equipment. On the fateful day of June 21, his work finished, he signaled for his crew to haul him down from his 900-foot perch. At about 200 feet the gas bag suddenly broke through its rope net and Lawrence and his camera plunged earthward. Fortunately, the force of the fall was broken by telephone and telegraph wires, and he landed unhurt. It took a second balloon mishap in Minnesota a month later to start Lawrence thinking about safer ways to send his camera into the air.

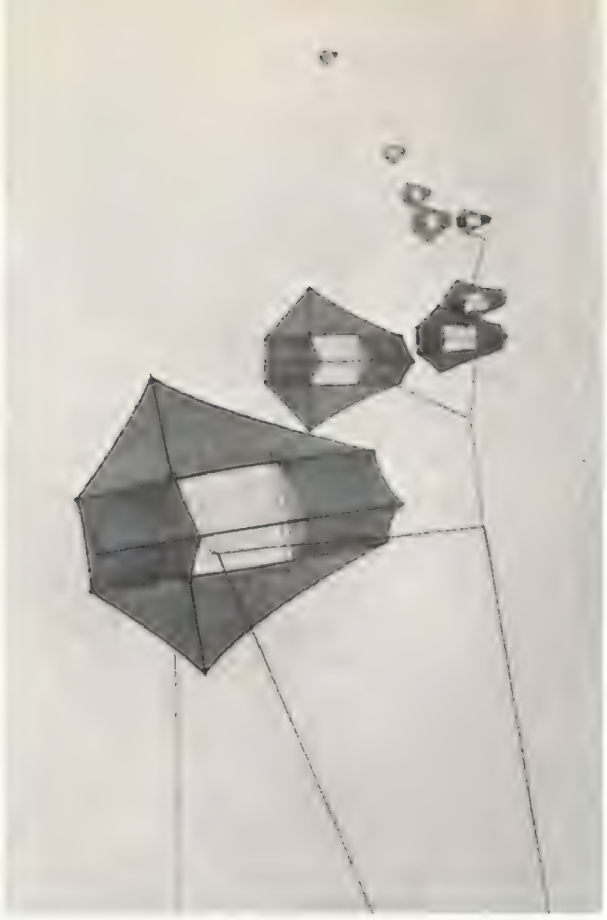
These were the days before powered flight, and experimentation in kite design and flying dominated aeronautical research. In the 1890s several experimenters had succeeded at getting men aloft on trains of kites. Magazines and newspapers carried accounts of the trials of Lawrence Hargrave in Australia, Fletcher Baden-Powell in England, and Army Lieutenant Hugh Wise in the United States. In that same decade William A. Eddy and Gilbert Totten Woglom got the attention of the American public with photographs they had taken with cameras suspended from kite trains. The very year that Lawrence suffered his balloon mishaps, Samuel Franklin Cody, an American living in England, successfully demonstrated his system of man-lifting kites to the British War Office. For a brief time before the coming of the airplane, kites received serious consideration as vehicles for aeronauts.

In 1902 Silas J. Conyne, a Chicago inventor, patented a kite for the purpose of carrying advertising banners above the city. Lawrence was impressed by the stability and lifting power of Conyne's kite and obtained the right from the inventor to build them. Sailing off on a kite was not what Lawrence had in mind, but using them to lift his camera seemed a possible alternative to dangerous balloons. If kite trains could lift a man into the sky, why not a large camera? He decided to follow the lead of Eddy and Woglom, but neither of them had ever sent up a camera of the size he had in mind. For the next few years Lawrence took time from his ground-based photography business to experiment with camera-lifting kite designs.

One after another he resolved the technical problems until all parts fell into place. He constructed a system that enabled up to 17 kites to be attached to the main kite line, though in practice he

Raymond, Lawrence's eldest son, helped out in early experiments with kite-borne cameras in Zion, Illinois.

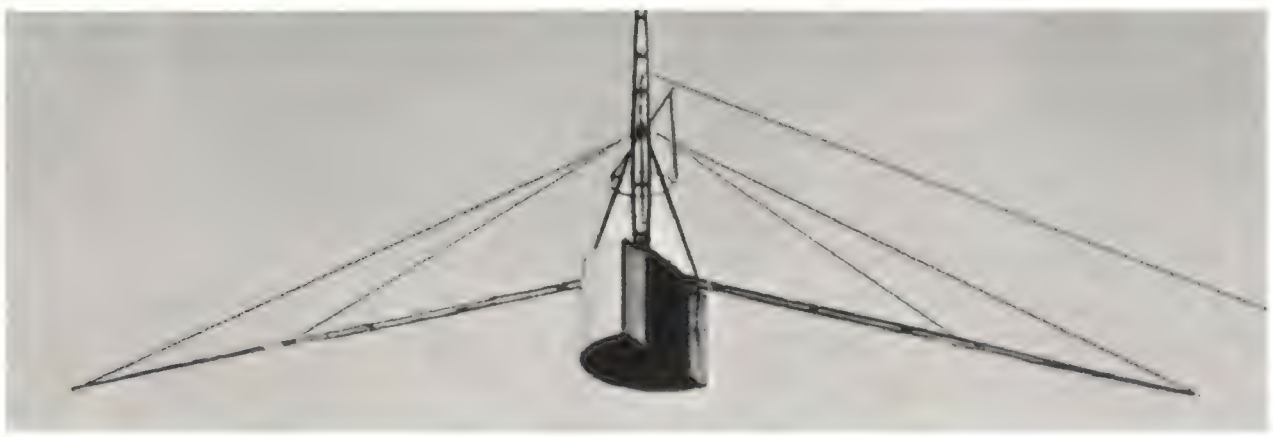
Although devastated by an earthquake just weeks earlier, San Francisco looked oddly tranquil from the air.



seldom used more than 10. To keep the kites from becoming entangled in the main line, he used six-foot bamboo poles as spacers between each kite and the main line. Controlling the pull of the kite train was accomplished by two men operating a winch. The camera itself was

Lawrence's kite train (left) included bamboo poles to keep the kites from becoming entangled.

The Captive Airship was stabilized by three poles with weighted cords hung from the ends.



positioned below the last kite in the train. In order to operate the camera from the ground, Lawrence added a solenoid that would release the lens when activated by a battery-powered device, which was connected to the camera by an insulated wire running through the main line.

The most challenging question, of course, was how a camera dangling in the wind could be pointed at a subject and kept still enough to make a clear exposure. The solution was beautiful in its simplicity. The camera was mounted in a cradle, which in turn was attached to the main kite line by a tripod-like set of arms with a clamp at the top. Finally, the cradle was locked into position with a rigid arm extending from the tripod apparatus to the kite line.

To keep the whole set-up from swinging like a pendulum, Lawrence attached to the base of the cradle three wooden poles 120 degrees apart and about 15 feet long. At the end of each pole was a lead weight of several ounces, and from each weight dangled a fine silk cord 120 feet long. The three cord ends were tied

Lawrence (left) designed and built this enclosed-cabin flying boat after his photographic career ended abruptly.

together and a three-pound lead weight attached at that point.

The sum of all these parts was what Lawrence called the Captive Airship. At the heart of the system were the cameras, and Lawrence built his own, using wood and aluminum. The two types he designed for aerial work were modifications of commercial cameras of the day. One was an ordinary flat-plate camera having a fixed-focus lens with the usual leather bellows replaced by a lighter and cheaper metal frame covered with black cloth. The other had two features that enabled Lawrence to make panoramic photographs: a film plane that was semicircular instead of flat and thus could accommodate very large pieces of film, and a fixed-focus lens that swung out horizontally on pivots to cover up to 160 degrees.

Since the cameras were mounted with their bases level and the kites were kept at a certain elevation, the lenses always pointed at the horizon. In order to record as much of the ground surface and as little of the sky as possible, Lawrence fitted his camera lenses below the horizontal mid-lines of the film plates. He made these cameras in several different sizes for a variety of purposes. The one that appears to have been used for the 1906 San Francisco photographs weighed 49 pounds.

In 1905 the Lawrence apparatus came to the attention of President Theodore Roosevelt, who saw possibilities for its use in times of war. Arrangements were made for a demonstration, which was conducted before a group of Army and Navy officers at Indian Head, Maryland, on May 22. This was followed a few days later by an attempt to launch the Captive Airship from a tugboat on the Potomac River. U.S. Navy Lieutenant L.H. Chandler reported to the Chief of the Bureau of Ordnance that further tests needed to be conducted at sea with the North Atlantic Fleet. With permission from the Department of the Navy, Lawrence and his assistants came aboard a battleship off New England on August 25 and worked there for nearly a week. The examining Naval officers concluded that the system of kites and cameras showed promise in spite of some problems. However, Lawrence withdrew his offer to sell the apparatus to the government when he could not get his price. Perhaps the only positive result of the various demonstrations is that they produced two U.S. Navy reports describing the Captive Airship in detail. Unfortunately, it appears that Lawrence himself never published anything about his methods.

The next significant event in his career as an aerial photographer was the San Francisco earthquake and fire. The "San Francisco in Ruins" photograph, more than anything else, brought him wide recognition and acclaim; it also reportedly brought him $15,000 for the publishing rights. After leaving the smoldering city, Lawrence traveled through California, making aerial photographs of Pacific Grove, San Jose, and Santa Cruz. The results, of course, were all for sale; Lawrence was, first and foremost, a commercial photographer.

Engaged by a Chicago financial firm with interests in western U.S. irrigation developments, Lawrence traveled through the region in 1908 taking bird's-eye photographs of project areas. That same year he returned to San Francisco and duplicated his panorama from over the bay in order to document the city's recovery efforts.

The end of his career as a commercial photographer was marked by a major endeavor. W.D. Boyce, a Chicago publisher, hired Lawrence to take charge of photography on an expedition to British East Africa. The objective was to get pictures of wild animals for a book Boyce was planning. No one had ever taken aerial night shots of wild animals before, and Lawrence took along two hydrogen balloons, an immense stock of iron filings and acid to generate hydrogen, a Captive Airship, towers, and plenty of flash powder.

The expedition occupied him from August to November 1909. His photography business ended shortly afterward. According to interviews with relatives, while he was in Africa his wife discovered he had been having an affair with one of his secretaries, and upon returning to the States Lawrence fled to California, taking his sons with him. During his absence, his business passed into the hands of two assistants.

In subsequent years Lawrence turned his attention to aircraft design. He spent several months in England trying to interest the British military in his designs, but in the end the British were more interested in his kite system. Lawrence also constructed several enclosed-cabin flying boats, but this venture proved unsuccessful as well. Nonetheless, before his airplane company folded in 1919 he managed to patent many aviation-related inventions. Says Thomas Yanul, a Chicago panoramic photographer and Lawrence scholar, "Lawrence could *always* raise money."

Lawrence died in Chicago in 1938. To appreciate the achievements of his early years, one really needs to see his photographs in the original form—the Library of Congress in Washington, D.C., and the Chicago Historical Society have the best collections. And knowing the methods he used to obtain such unusual results helps one to see that Lawrence was something of a technological genius, a photographer whose work was never matched by any of his contemporaries. George R. Lawrence, the first commercial aerial photographer in the United States, stands alone in his inventive brilliance.

Allied-Signal Aerospace Company

Allied Signal

A Spaceship Named Orion

Mars or bust—with an atomic tiger in the tank.

by Bill Wagstaff

Paintings by Web Bryant

From my childhood it has been my conviction that men would reach the planets in my lifetime, and that I should help in the enterprise. If I try to rationalize this conviction, I suppose it rests on two beliefs, one scientific and one political:

(1) There are more things in heaven and earth than are dreamed of in our present-day science. And we shall only find out what they are if we go out and look for them.

(2) It is in the long run essential to the growth of any new and high civi-

Theodore Taylor (left) now lives in western New York, where he is studying the greenhouse effect. Today he advocates solar electric propulsion for travel to Mars, the asteroids, and perhaps even Mercury. Freeman Dyson (right) resides in California and serves on the National Air and Space Museum's Research Advisory Committee. The two former colleagues still keep in touch.

lization that small groups of people can escape from their neighbors and from their governments, to go and live as they please in the wilderness. A truly isolated, small, and creative society will never again be possible on this planet.

To these two articles of faith I have now to add a third:

(3) We have for the first time imagined a way to use the huge stockpiles of our bombs for better purpose than for murdering people. Our purpose, and our belief, is that bombs which killed and maimed at Hiroshima and Nagasaki shall one day open the skies to man.

—Freeman Dyson, *Disturbing the Universe,* Harper & Row, 1979

In the summer of 1958, at the bidding of friend and fellow theoretical physicist Theodore Taylor, Freeman Dyson took a leave of absence from the Institute for Advanced Study in Princeton, New Jersey, and moved to California. Taylor wanted Dyson on a team he was assembling at General Atomic Corporation, a nuclear reactor developer in San Diego, to work on a wildly innovative concept for interplanetary travel.

In 1949, just out of college, Taylor had gone to work at the Los Alamos Scientific Laboratory (now the Los Alamos National Laboratory), becoming an expert designer of small, efficient fission bombs. While working on these weapons, he became interested in peaceful applications for fission explosives. In the mid-1950s Los Alamos physicists Stanislaw Ulam and Cornelius Everett came up with the idea of propelling a spacecraft with nuclear bombs, a concept that captured Taylor's attention. With the possibility of nuclear spaceflight fresh in his mind, he left Los Alamos in 1956 to join General Atomic.

With the launch of Sputnik 1 in October 1957, spaceflight became a reality, and interplanetary travel suddenly seemed possible. Taylor quickly persuaded General Atomic to let him write up a funding proposal, and in April 1958 he presented it to the Advanced Research Projects Agency (ARPA) of the Department of Defense. It was titled Project Orion.

Taylor's proposal described a spaceship that would be driven by thousands of sequential nuclear explosions. Both Taylor and Dyson wanted to *travel* in space—not merely orbit Earth but poke around the far-flung corners of the solar system and perhaps even farther. Their motto: "Saturn by 1970."

But the only rockets available at the time used chemical fuel, and chemical rockets were too slow for traveling anywhere beyond the moon. The massive quantity of fuel that chemical rockets require to escape Earth's gravitational pull makes spaceflight slow and expensive. A pound of nuclear fuel contains more than 10 million times the potential energy of a pound of liquid hydrogen and oxygen. A series of nuclear explosions timed to go off every second or less could propel an Orion spaceship at 100,000 mph. (NASA's Apollos made their way to the moon at a comparatively sedate 25,000 mph.)

An 80 million-mile round trip between Earth and Mars on chemical propulsion would take one and a half to three years, whereas an Orion flight to Mars and back might take a couple of months, according to Taylor's calculations. An Orion spaceship could journey to Jupiter in less than a year. And it could fly there straight from Earth, avoiding the time-consuming, baroque trajectory that relies on a slingshot turn around a planet's gravity field.

ARPA granted Project Orion a $1 million contract in July 1958, and Taylor's team settled in at General Atomic's lush new digs outside San Diego to flesh out the details of one of the most powerful space propulsion systems ever conceived.

The first full-blown Orion design was for a cylindrical spaceship, 100 feet long and 34 feet in diameter, with the tapered head of a conventional rocket and scaled to fit on top of a Saturn V booster. At its base would be a massive aluminum dish called a pusher plate. The plate would be connected to the

Christopher Springmann

body of the spacecraft by a two-stage shock absorbing system consisting of a pile of gas-filled, doughnut-shaped cushions and a set of 50-foot gas-filled metal cylinders; these components would work like the springs and shock absorbers in an automobile.

The fuel for a round trip to Mars would be a couple of thousand nuclear bombs, more for a longer mission or a heavier load. An ejection mechanism similar to a soft drink vending machine's, using compressed nitrogen as a propellant, would spit out increasingly powerful bombs every second or so, sending them down a shaft and through a hole in the pusher plate. As the bombs exploded about 50 feet from the hole, plastic on top of the main explosive in each bomb would disintegrate into a spray of ions that would add punch to the thrust-generating shock wave produced by each explosion. The shock waves would compress the shock absorbers, which would then rebound, cushioning the crew.

Some flight plans called for as many as 10 explosions per second. "It would have been a bumpy ride, but the overall G levels would have been low," Dyson says now. "The crew cabin during the propulsive phase might have gotten a little noisy, but there would have been enough springs to make it comfortable." Tests using chemical explosives and gas plasmas to simulate the blasts indicated that the spacecraft could withstand the repeated pummeling of the explosions provided they took place at carefully controlled intervals and distances. A coating of silicon-based grease, replenished as needed, would protect the pusher plate from erosion by the searing heat. But the boost phase wouldn't last long; most of the journey would consist of coasting at high speed through deep space.

Spacious crew quarters would be located at the front end of the spaceship. Various mission plans called for crews ranging in size from 12 to several hundred. Because Orion's propulsion would generate intense radiation, the design called for a special shielded boost-phase crew chamber.

The designers originally planned to launch their spaceship from a nuclear test site in Nevada, but they switched to space-based launchings because of the problem of radioactive fallout. The Orion would be launched from Cape Canaveral by a Saturn V chemical rocket to Earth orbit, and additional Saturn launches would transport crew members, propellant bombs, and additional supplies to the spaceship before its departure into interplanetary space.

In July 1959 ARPA turned the project over to the U.S. Air Force, which classified the work. The Air Force didn't quite know what to do with the concept; it had no deep-space missions in mind. "The Air Force backed Orion mainly out of a desire to support interplanetary missions. There were people in the Air Force who believed in the program," Dyson says. "To maintain their support, the Air Force had to invent a military mission, but no one took that seriously. The military mission kept slipping through the cracks."

One adventurous Air Force officer actually went so far as to prepare a grandiose Orion proposal, calling for the development of enormous nuclear space battleships. The logical question was: What would you do with them? The Soviet Union didn't have plans for battling the United States somewhere out near Jupiter. With no enemy in sight, the idea went nowhere. Meanwhile, Dyson had already started thinking about an interstellar Orion measuring as much as a mile in diameter and propelled by a million hydrogen bombs.

Successful flight tests of an improbable Orion vehicle variously called the Pogo Stick (that's what it looked like), the Put-Put (that's what it flew like), and the Hot Rod did take place at Point Loma, an old Atlas missile engine test site overlooking the Pacific outside San Diego. Pulse propulsion was provided by high-energy chemical explosives concocted by Jerry Astl, a Czech refugee who learned how to blow things up as a member of the underground resistance during World War II.

The last and most successful of these flights took place in October 1959. The test vehicle had five hand-formed, two-pound, high-explosive plastic charges attached by three-foot primer cords and detonating microswitches, as well as an ejection system powered by compressed nitrogen. The three-foot-diameter, 250-pound spaceship took off from its launch pad on the power of five explosions in less than one second. When the Hot Rod reached an altitude of sev-

eral hundred feet, a parachute popped out and floated it gently to the ground in front of a blockhouse filled with jubilant General Atomic workers.

Work on the spaceship proceeded. NASA had an interest in manned flights to Mars, and it joined Project Orion as a co-sponsor with the Air Force between 1963 and 1964. But NASA's primary mission, to run a race with the Soviets, forced the agency to focus on ways to put men in space as quickly as possible. Chemical rockets were proven, but bomb-powered spaceships were years away from flying.

Although neither the Air Force nor the space agency could come up with a mission for Orion, it was the nuclear test ban treaty of 1962 that put an end to the project. The treaty prohibited nuclear testing in the atmosphere, in the oceans—and in space. Above-ground testing planned for the Orion nuclear propulsion technology would be a violation of the treaty, and even space-based launchings were out.

Despite this setback, Taylor continued campaigning to save his project. "What we proposed to do was continue engineering development with no above-ground tests for three years," he recalls. "If Orion then looked sensible, the United States would go to the Soviets with the technology and then draw up an exception to the treaty. We were prepared to share the technology with the Soviets so they didn't have to feel threatened by what we were doing."

NASA, the Department of Defense, and the Atomic Energy Commission did not immediately reject the plan, but ultimately the idea of cooperating with the Soviets was deemed "too politically utopian," says Taylor. Besides, the plan did not eliminate the risk of radioactive fallout from a space-based Orion launch.

"The amount of radiation in the lower atmosphere would be small," Dyson

The Orion would probably have to carry shuttles for the descent, but their added mass would be trivial.

says. "But some radiation from the blasts needed to leave Earth orbit would have been trapped in the magnetosphere, which curves to Earth at the poles. Radiation trapped in the magnetosphere would follow the magnetic field lines down to the poles. While movement along those lines is very slow, the radiation, mostly in the form of radioactive strontium and cesium by-products, would reach Earth's surface about two years after the explosions."

At the time the Orion concept first surfaced, the public had already begun to worry about nuclear weapon buildup and exposure to nuclear radiation. But nuclear power still had a good reputation among industry and government officials, Taylor says, and Orion passed muster with them. By the time the test ban treaty was signed, however, officials were forced to acknowledge the public's growing concerns. Permitting radiation to pour into the atmosphere in the name of space exploration had become unacceptable.

The Air Force officially terminated the project in 1965, and when nobody offered to take it over, Project Orion quietly gave up the ghost. It had cost about $10 million. All that was left in the end were a few pieces of hardware, some grainy movie footage of the final test flight, glossy artist's conceptions of bomb-powered spaceships streaking through space, and the remains of more than 300 technical reports, many of which are still classified. The Orion test vehicle that took off from Point Loma in October 1959 now hangs in the "future" section of a rocketry exhibit at the National Air and Space Museum. It's the largest known piece of physical evidence that Project Orion ever existed.

NASA is now working on advanced chemical rockets to take people to Mars. But tucked here and there within the space agency are a few rebels who still dream of nuclear-powered spaceships for trips around the solar system.

"I still have a persistent dream that one day man will use the most destructive devices he has ever conceived for extending his reach to other worlds," Taylor wrote in the *Annals of the New York Academy of Sciences* in 1972. Now living in West Clarksville, New York, Taylor teaches at the University of California at Santa Cruz. Lately he's been studying a method of solar electric propulsion for interplanetary travel: lightweight sheets of solar electric cells could generate enough power to drive an ion accelerator that would fire out charged particles at speeds up to 10 times Earth's escape velocity. A spacecraft propelled by such a system would be an efficient vehicle to travel to Mars, the asteroids, and even Mercury, he says.

Dyson still works at the Institute for Advanced Study in Princeton. He has written that the 15 months he spent working on Orion were "in many ways the happiest of my scientific life." In *Disturbing the Universe,* Dyson includes the following letter, which he wrote to Manhattan Project director Robert Oppenheimer on the day the Orion program ended:

You will perhaps recognize the mixture of technical wisdom and political innocence with which we came to San Diego in 1958 as similar to the Los Alamos of 1943. You had to learn political wisdom by success, and we by failure. Often I do not know whether to be glad or sorry that we escaped the responsibilities of succeeding. —

NASM

The Lear Fan Saga

Sometimes not even love and money can keep a project alive.

by T.A. Heppenheimer

Lear Fan Photo

The winds of January are cold near Reno, Nevada. They sweep down from the nearby Sierras and blow across the stark concrete of a runway, where a corrugated-steel hangar rattles hollowly amid the gusts. Until recently, peeling paint on the hangar's side read "LEARFAN." Part of a corporate logo, in colors that were once bright red, green, and blue, still shows. Yet the place has not been completely abandoned; a light shines in a corner window. Virtually a candle to the memory of her late husband, it comes from the office of Moya Lear. Eager and active, she comes to the office every day, hoping for a phone call. It is to come from a savior, an investor who will put the Lear Fan effort back together and vindicate the vision embodied in the last airplane to be designed by her husband.

He was William Powell Lear, and he thought of himself as one of the last great inventors, a latter-day Thomas Edison. He believed he could pull major innovations out of a hat by relying on intuition alone. And with astonishing regularity he did. Lear held over 150 patents. He invented the car radio, made major contributions to aircraft navigation equipment and autopilots, and invented eight-track stereo even as his Learjet was lighting up the skies.

Everything he touched bore his name: Learjet, Learium, Learecorder, Learepeater, a real estate development called Leareno. There was a compulsiveness about him, too. He was in constant motion, always looking for a challenge. He had a continuing passion for other women, sometimes for casual relationships, other times for quite serious ones. As for his engineering activities, "there were six or seven things going on at once, all due Wednesday and undercapitalized," one of his managers said. "Lear was a guy with a new idea every day and we'd chase off in a different direction. He never exercised the discipline to see them through. He robbed yesterday to feed today."

But that wasn't how the world saw him. He had captured its fancy during the 1960s with his Learjet, a converted Swiss fighter. It had fulfilled the Walter Mitty fantasies of a generation of staid business executives, turning them into aeronautical hot rodders. Other business jets were available, but Lear grabbed the celebrity endorsements—Steve Lawrence and Eydie Gorme, Danny Kaye, the Smothers Brothers, singer Roger Miller, TV newsmen Peter Jennings and Howard K. Smith—and turned the Learjet into one of the more glamorous symbols of the '60s. With that plus eight-track stereo, Lear could open any door.

His hot-shot entrepreneurship was a marked departure from the usual workings of the business aviation industry. It was a conservative field that invested little in research and lagged behind the airlines in technology. It had come late to the Jet Age, and its major manufacturers—Beech and Cessna—were closely linked to general aviation, where change came still more slowly.

Bill Lear re-invaded the field in the mid-1970s with a design

Bill Lear's last design was typically new and daring. But could the project get off the ground without its inventor?

Brilliant, restless, charming, explosive, Lear was used to clearing obstacles through sheer force of will.

Lear Fan Photo

called the Learstar 600. It called for an advanced wing and new fuel-saving turbofan engines. Lacking facilities to build such an airplane himself, in 1976 he sold the design to Canadair, which bought it for the Lear name and as a spur to its own engineers. Bill Lear didn't realize that. Canadair completely modified his design, while playing him against its own engineering team by encouraging him to put forth a design for another airplane. When Lear learned at a meeting with Canadair executives that the company was only trying to keep him away from the Learstar project "he was *white,*" Moya recalls. "It was a bad time for him. I just put my arms around him and said, 'Honey, it's a great airplane, and someday we'll take it someplace.' "

In Reno, at his LearAvia firm, two of his managers decided Lear needed a new airplane to work on. Richard Tracy and Rod Schapel could see he was aging and declining in health; in Tracy's words, "Bill's going to die if he doesn't get one last shot." Schapel set to work on a concept for a small business turboprop, based on an idea that Lear had kicked around as early as 1954. This was joining together two turbine engines to drive a single pusher propeller, providing a margin of safety following an engine failure.

Lear believed that when twin-engine aircraft crashed after an engine failure, it was usually due to pilot error amid the strain of coping with the unbalanced thrust from the surviving engine. As he put it, "The second engine always has enough power to get you to the crash site." If the two engines drove a single prop, the resulting "centerline thrust" would avert the violent yawing that occurred when one engine shut down. The pilot could then simply push both throttles forward and determine at leisure which engine had the problem.

At first Lear had paid little heed to Schapel's new design. But shortly after returning to Reno from Canadair, he found he would have to lay off some people. He didn't like that. Now he grabbed greedily at the design, hoping it would make him the daring entrepreneur of before.

He quickly added several characteristic touches. The most significant was that the airplane would be built entirely of carbon-fiber composites. In the mid-1970s these materials tantalized the engineering mind. Lighter than aluminum, they also offer considerably more strength. Lear had prepared designs featuring composites for the Learstar 600. But now he would go after something much more far-reaching: an entire airframe built of them.

Lear was like a kid in a candy store when it came to technology. He would grab anything in sight without worrying about the results. Composites were also attracting interest at Boeing, but it was slow going. That company was introducing the materials gradually on successive generations of jetliners as they proved themselves in service. Lear would ride with an all-composite design on his first try.

His proposed power plant also raised questions, for it fit no existing category of aircraft engine. Should it count as a twin-engine design? Or would its single propeller, driveshaft, and gearbox relegate it to the single-engine world? Lear wouldn't accept single-engine status because twin-engine craft were what the market demanded. Then how would his propulsion be qualified by the Federal Aviation Administration, which had no rules to go by? Answering such questions would demand what the Boeings of the world call "research" and leave to NASA. Lear had different ideas. "How are you going to maintain the engines?" his son John asked at a typically tense family meet-

Lear Archives

Lear's dying words, "Finish it," became a battle cry for his widow and his company. Bent on carrying out his wish, they took the Lear Fan from paper to prototype within two years.

ing. "We don't need any maintenance," he replied.

Under his strong hand, the Lear Fan took shape during 1977 and the early months of 1978. Then, quite suddenly, Lear learned he had leukemia. It progressed rapidly, and at age 75 he knew he did not have long to live. He met the news in typical form. Two days before he died, he resisted going to the hospital. "I want to go to the plant," he told Moya. "I want to beat on my boys." When he died, his nurse was at his side stroking his hand. He thought she was Moya. "Finish it, Mommy," he gasped. "Finish it!"

When Lear died, the airplane existed only on paper. But Lear had a successor, a longtime associate named Sam Auld, who now was company president. Auld had spent much of his career in Lear's shadow, and he needed a good man to run the program. He found one in Bill Surbey, a project manager from Cessna. Surbey had been program manager for the Cessna Citation, a top-of-the-line business jet with a budget of half a billion dollars. A calm and confident man, he had dreams of becoming a company president. But Cessna had a president; he'd have to go elsewhere for his chance, and thus he fell in with the dreamers at Lear Fan.

Auld had never developed or built a new aircraft, and didn't really expect to start even now. He hoped to build a prototype, fly it as a demonstration, then sell the design to another firm. All this would cost only $20 million, which looked to be available. But this plan gave Surbey a rather soggy feeling. "It just doesn't work that way," he argued. "The aircraft industry is not set up to build other people's designs. Beech, Cessna, even Canadair are not job shops. They have large engineering staffs to prepare original designs, and they aren't likely to buy ours. If we want to see the Lear Fan go ahead, we'll have to build a factory and do it ourselves. And that will cost $100 million."

Although Auld had his hopes in Canadair, he was ready to start beating the bushes. He was solidly plugged in to the network of Lear's fans and knew a variety of investment bankers. Thus he made his way to Oppenheimer & Company, a New York outfit that specialized in attracting research-and-development money from private individuals to produce tax shelters. Learjet owners, who knew little of designing new aircraft but who cherished the name of Bill Lear, thus would have the chance to back their boy's newest hot rod.

The Oppenheimer people wanted to make sure the Lear Fan had enough financing to actually go into production before they would chip in their share, however. Another old friend of Lear's, aircraft builder Robert Adickes, knew that British prime minister Margaret Thatcher was looking for opportunities to build factories in economically depressed Northern Ireland and suggested that Auld talk to the British government. Auld flew to London, but the support didn't come easily. "There are all sorts of tire kickers who like to talk about such projects. But to nail the money down, to make it happen—that's something else," he says.

On a dark and rainy evening in February 1980, it came together. A group of Thatcher's ministers met in a room of Parliament and decided to contribute $50 million. The Oppenheimer group then chipped in $30 million. With another $20 million already available from other sources, Lear Fan would proceed.

To build confidence among the investors, Oppenheimer insisted on the naming of a new company president, a well-

Bettmann Newsphotos

In the mid-1930s Lear's radio direction finder, the Learoscope, put him on the path to wealth and recognition.

Lear Archives

The steam engine was to run off a "miracle fluid," Learium. In the end it proved to be simple water.

Bettmann Newsphotos

Lear's autopilot earned him the prestigious Collier Trophy—and a handshake from President Truman.

Lear Archives

The inventor's plans to end air pollution with a steam engine attracted the attention of Ralph Nader, among others.

Bettmann Newsphotos

In 1956, Lear, accompanied by his wife Moya, became the first private pilot to land an airplane in Moscow.

ASM

After a troubled start, the Learjet secured Lear's fame and made his name a household word.

ear Archives

With friend Art Linkletter: the inventor used celebrities to help nhance the Learjet's status.

ear Archives

Debuting in 1974, Lear's noisy, lurching steam-powered bus was a iebacle; the Lear Fan was to be his vindication.

known executive from one of Lear Fan's competitors. That would show that Lear Fan could attract a leader in the industry. Sam Auld was kicked upstairs, leaving him quite bitter: "I'd been working night and day, seven days a week, to raise the $100 million. And then three weeks later I was no longer in charge."

His replacement was Linden Blue, executive vice president of Gates Learjet, which made and sold Learjets after Lear sold the rights to Gates Rubber in 1967. A longtime associate of Lear's who has little love for Blue says, "He spent money like a drunken sailor. Linden was about to get the boot from Charlie Gates because of his prolific spending when we were so fortunate as to pick him up. The guy was uncanny at spending money. He spent $80,000 fixing up his office, adding a bathroom and a kitchen. After the whole airplane was pretty thoroughly designed, he bought a CAD-CAM computer for $750,000. He put in a data telemetry system for the aircraft that was second only to NASA's. We all got new cars, too. And this attitude soon pervaded its way down to the janitors: 'Wow, we've got all this money, let's buy a lot of things.' "

Blue's background was in marketing, and he decided that to sell more airplanes, the design would have to change. The cabin was to be lengthened by a foot. ("That change alone cost about a million dollars an inch," says Robert Jacobsen, the chief engineer.) The cabin door was in the wrong place, too. Blue's objections happened to coincide with some manufacturing problems that were troubling the technical managers. Because they had little experience with composites, they had come up with a design that would be hard to build. Now they thought they could make it simpler and more manufacturable, while at the same time accommodating Blue's design changes.

The changes would greatly drive up costs, however. The engineers were eager to apply the latest in composites and improve their designs, but the delay to the program would be expensive. They now had a large and costly factory near Belfast to support, and amid these delays its people would be working to no good purpose, all the while drawing salaries.

To judge and winnow those changes, the company needed a strong hand in engineering management, but the man with the needed experience, Bill Surbey, was spending most of his time on other things. The company needed someone to show the flag in Northern Ireland, and Surbey found himself volunteered for this. It meant commuting between Nevada and the Emerald Isle every two weeks. During his half-month in Belfast, he had no way to keep up with what the engineers were doing. And even during his two weeks back in the States, when he wasn't recovering from jet lag he was spending a lot of time meeting with bankers and investors.

Nevertheless, the Lear Fan effort was building an airplane. By agreement with the British, the first flight of the prototype was to take place before the end of 1980. On the afternoon of December 31 the company was conducting high-speed taxi tests prior to takeoff. Suddenly a brake overheated and a tire caught fire. The airplane was at the end of the runway, enveloped in smoke. Everyone's hopes sank along with the sun. A crew rushed out and quickly changed the brake and tire, but it was near sundown and the engineers decided to postpone the flight.

The next day, January 1, 1981, the airplane flew success-

Lear Fan Photo

fully. The British good-naturedly declared that the Lear Fan had indeed made its first flight in 1980—December 32, 1980. Torch Lewis, vice president for sales, remembers the moment: "We had the money, we had the airplane, we had sold 180 of them. The world was our oyster." Bill Lear's genius appeared to have been vindicated. He had dreamed boldly, designed with audacity—and there it was, a real airplane in flight. To the British and the other investors, everything looked to be in excellent shape.

It wasn't. By early 1982 the handwriting was on the wall: the company needed a lot of money, and soon, but its large debt made it unattractive to investors. In April Linden Blue left to become president of Beech. The British were getting antsy as well. Their laws would not allow a company to continue to operate if it had no prospect of success. In the States a firm can use the courts to stave off its creditors in an effort to survive, but British law demanded that such a company sell its assets and go out of business.

Rescue came in the form of Prince Sultan bin Salman bin Abdul Aziz Al-Saud. Prince Sultan, an aviation buff and an early buyer of Lear Fan orders, had flown aboard the space shuttle

Engineers worked feverishly to get the first prototype past preflight testing (above) and into the air.

When the prototype finally flew, missing its 1980 deadline by one day, the project appeared to be a success.

Challenger when it launched the Arabsat communications satellite. His financial advisor, Bob Burch, a Denver banker and oil wildcatter, persuaded him to buy out Lear Fan. Burch, who had no aviation experience, was named the company's new president.

Aware that he lacked appropriate expertise, Burch brought along a friend, Allen Price. Price had been an aircraft salesman and had conducted an evaluation of the Lear Fan for Burch. Burch proceeded to fire Sam Auld and Bill Surbey, along with a number of other experienced people. What's more, as Moya Lear remembers, "He took Bill's portrait down! From its place at the top of the stairs, and it had been there forever. He fired my secretary, who'd been with us 16 years. This company had a spirit, but when Mr. Burch walked in, it was over."

What was not over were the engineering problems. They had not yet even begun.

The first bad one showed up in December 1982, when a wing was being stressed under load. Suddenly there was a loud crack as its interior structure gave way. It had been designed using standard techniques for aluminum. But carbon-fiber composites demand a different approach. It took a year to make the fix. And all through that year the Belfast factory continued to eat into the capital. Nor was this wing problem the last of its kind. In a 1984 test a fuselage was put under pressure and bent. It blew up with a loud bang. The fuselage was rebuilt and that problem fixed, but when it was pressurized and bent in the opposite direction, it burst again.

The power plant problem proved to be even more intractable. That one had not been obvious at the outset, to be sure. The arrangement of two turbine engines powering a single propeller through a gearbox was quite new for fixed-wing aircraft but was a standard design for helicopters. Pratt & Whitney had a "Twin-Pak" in which a pair of turboshaft engines drove a single rotor through a common gearbox. The Lear Fan's design was less complex, and its managers anticipated that the FAA could certify it using the requirements for the Twin-Pak.

Lear Fan Photo

Lear Archives

The British government declared the date of the first flight to be December 32, 1980. A postmark commemorates the day.

The FAA was skeptical. Helicopters rarely flew long distances over the ocean and they had an extra margin of safety: when their engines failed, their rotors' ability to generate lift simply by freewheeling could allow them to glide safely to a landing. Nevertheless, the agency was willing to proceed with helicopter-like rules, at least at first.

One of their rules covered the possibility that the Lear Fan's gearbox might lose its oil during a long flight at sea. That was unlikely, but just in case, the FAA wanted the gearbox to "run dry"—without lubrication—for 30 minutes, a requirement that the Twin-Pak and similar helicopter arrangements had had to meet.

In an early test the gearbox cracked and there was an oil leak. Lear Fan engineers traced this to a flaw in the casting and introduced stringent inspection procedures to prevent a recurrence. The FAA was not mollified and upped the requirement to 90 minutes. This meant the power plant engineers would have to design and get certified an entire new system, one that would spray a fine mist of oil onto the gears if necessary. One more system, in short, that might go wrong.

In another test, the engineers ran the power plant for 200 hours on the ground. During part of the test, the propeller spun within an enclosure with no circulating air, subjecting it to unusually severe vibration. It flunked. A type of wear from friction called fretting turned up at the junction between the main gear and the propeller shaft. Back went the gearbox for a redesign, with another 200-hour test following. The fretting was reduced, but it was still there. Clearly the gearbox needed still another redesign, another 200-hour test.

These problems were annoying, but they were typical of the sort of thing any engineering group faces in trying to push the state of the art. But because of the large size and shaky finances of the Lear Fan operation, the delays couldn't be accommodated. The Belfast plant was producing no sales for Lear Fan, yet it had to be fed. And the company's money was dwindling. It had $210 million in all, but that wasn't enough. When each major problem arose the management would stretch out its schedule, lay off some people, and try to carry on. After they had done this several times they were left with only a few million dollars and very little in the way of a staff that could solve the problems. As 1984 turned into 1985, Bob Burch was saying that it would take $50 to $80 million more to finish the project—money that was nowhere in sight.

And while this financial noose was tightening, other aircraft firms were offering attractive alternatives. All along, the promise of the Lear Fan had been that of a pathbreaker, featuring three key elements: composite materials, twin-engine operation, and centerline thrust. But by 1985 buyers could look ahead to the Beech Starship, initiated by Linden Blue, which offered the first two of these three. Robert Adickes was pursuing the Avtek 600, with these same two features. Amid the delays and the problems, the Lear Fan began to look like a pioneering effort whose time had already come and gone.

So it was that in May 1985 the company filed for bankruptcy. Its directors listed $475 million in debts and only $7 million in assets. But before its collapse was final, one more act was played out.

That month a man approached Moya Lear, describing himself as Dominic Ferretti, an Italian financier. He claimed he had access to $257 million with which to save Lear Fan, and he would be glad to help if she would contribute $65,000. She and her executives proceeded to celebrate with a party in a Reno hotel. But the party was crashed by sheriff's deputies, who arrested the "financier." A parole violator from California named George Upton, he had a record of perpetrating scams, including a conviction for grand theft. And with that, the Lear Fan story appeared to be over.

It isn't merely a story of mismanagement, of entrepreneurs misjudging difficulties and running out of funds. It is much more. The Lear Fan story shows what lies beyond success, beyond achievement, beyond the end of the rainbow.

William Powell Lear had been neither an engineer nor an entrepreneur, but an artist. A high school dropout, his technical knowledge was largely a matter of feel and intuition. He had lived his life according to the conviction that technical progress was a matter of will, of daring to break through conventional thinking to seize the moment. It was an attitude that appealed enormously to other engineers, trapped in stodgy organizations. That was why Bill Surbey and others had left solid jobs at places like Cessna for him.

If that had been all Lear offered, he might have gained a strong reputation within the field of aeronautics while remaining little known in the world at large. But he did more. His Learjet was more than a product; it became a legend. He himself was more than a company president; he was a cult figure. He would find backers for anything he proposed.

But even if his Lear Fan had succeeded, the program would not have turned the sky white with the new aircraft. By the mid-1980s there were simply too many business jets and turboprops on the market, along with a sizeable number of used aircraft for sale. A successful Lear Fan would not have repeated the triumph of the Learjet. At most it would have been a modest success to cap Lear's career.

And still his widow tends the dying embers of this, his last vision. In her mind the project has suffered setbacks but remains feasible, waiting only for the magic kiss of money. Moya Lear is in her 70s now, but still she clings to the faith that she will finish it and fulfill her husband's dream. That is why she drives to that hangar each day, where the runway looms in emptiness and winds blow cold from the Sierras in January. She greets her secretary, answers her mail, and waits for the phone to ring.

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A Pilot's Requiem

Illustrations by Paul Salmon

Three years after winning the Six Day War in June 1967, Israel was still fighting a costly war of attrition with Egypt in the Sinai and with Syria on the Golan Heights. The conflict frequently took the form of Egyptian or Syrian artillery barrages, sometimes coupled with hit-and-run attacks by low-flying jets.

On May 12, 1970, the Israeli Air Force responded to a Syrian attack on the Heights. One of the pilots who participated was Asher Snir. By the time of his death from cancer two years ago, Snir, 44, had downed 13 enemy aircraft, held most command positions within the air force, and achieved the rank of brigadier general.

Snir's account of his experiences on May 12 originally appeared as a prologue for the book G Suit: Pages in the Log Book of the Israel Air Force. *This condensed passage, which appears here for the first time in English, was translated by Arye Ephrath.*

It was once the custom that on the night of Independence Day, all the Air Force air crews got together at one of the bases, enjoyed the excellent entertainment programs prepared by the various wings, and then alternated between dancing the horah with a cast of hundreds and downing booze until all were soaking wet, sauced to the hilt, and glowing with temperatures hot enough to disintegrate live proteins. In 1970 this was still the way to celebrate, and whoever thinks that it isn't proper—not even just once a year and with good cause—still has got a lot to learn. I plead guilty to doing my fair share of drinking, and to having my uniform soaked with my own perspiration and that of my neighbors in that endless horah circle, and I confess that I was unconscious as I drove later from Hatzor Air Force Base to Tel Noff, and that I cannot remember how and when I got into bed at dawn.

Tomorrow morning—that is, noon—is here, and I wake up very cautiously, by force of habit getting myself into the flight suit and boots. I take my bathing trunks and a towel and go down to the squadron to verify that all is well, to manage whatever needs to be managed, and to go to the beach. The friendly forces assemble slowly, sit around a lot, and get themselves

organized with an utter and wonderful inefficiency, sleepy-eyed, for the trip. Two will stay behind on ready standby—Amos Amir, the squadron commander, and Yitzhak Nir.

As we all shuffle around the siren begins to wail, and in an instant the slow foxtrot changes into a rumba: Amos and Yitzhak hop into a jeep and speed to the airplanes at the intercept position as Operations announces over the loudspeakers that this is a real scramble and that they want another pair right away. I am first in the truck with my G-suit and helmet and I gallop, half-dressed, to the airplanes. We all know that things have been heating up in the north since morning and besides, for years I have had a guiding principle: Grab every chance and eventually there will be a reward.

In a minute I am tied and connected and now I taxi to the runway where Amos is waiting for me. Afterburners, takeoff, a sharp bank and we are on our way north, to the Golan Heights.

En route the controller tells us to hurry, that the Heights are hot: there has been artillery fire, Syrian airplanes have attacked in the north and near Mount Hermon, and there are more of our flights en route to the area. The Heights are full of small columns of smoke, an unmistakable sign that a war is going on. We patrol northward and southward, straining our eyes to find the opposition.

All of a sudden Amos says, quickly and quietly, so as not to be overheard, "Come with me!" and he is already dropping like a rock. On the way down his two wing tanks fall away in clouds of fuel vapors and I jettison mine too, without knowing who or what exactly he is jumping.

Mount Hermon is looming large on our right, its peak high above us, when we pull out of the dive in one of the mountain's western valleys and I see the cause of the commotion: a lone MiG-17 chugging northward, running home into the border area between Syria and Lebanon. He has not seen us. I am a little sad. Amos, who is about 1,000 meters ahead of me, will shoot him down unceremoniously, and it really is not fair. The MiG is all alone, already in front of us, and does not know that he is about to confront a squadron commander and his deputy who, between them, have already put more than one MiG squadron out of business. No, it is not fair. Not to mention that he is in a MiG-17, which is no match for our Mirages. But then, this "no match" business is a booby trap: there are flight regimes, in the lower- and medium-speed ranges, in which the MiG-17 outturns the Mirage, and whoever is seduced into following a MiG into these territories will get nailed but good.

Amos is closing fast on the MiG, but just as he gets into firing range the MiG breaks sharply up and to the right. He has seen us in time. It was a good maneuver on the MiG's part, at the right time and in the right place. An excellent maneuver. Amos pulls up and I enter for a pass and I see the MiG diving, turning sharply into a dry river bed and presenting his entire back across my windscreen—the large, swept wings, the stubby nose, the high tail behind the round fuselage. I configure the gunsight, estimate the range. Just as I am about to fire the MiG twists forcefully and drops even lower.

Damn! Screwed up my pass, that man, and I pull out and Amos enters. The man in the MiG takes advantage of the short respite to drop closer to the valley floor, to turn north, and to gather some airspeed, which he will need to continue the fight.

I pull up and roll inverted to check whether I have another chance—or is Amos shooting him down right now? I see the MiG break again just in time, flying practically on the deck, successfully frustrating Amos' pass. I am on my way in.

The valley is getting narrower as we move northward, with a vertical wall growing on either side, and the difficult terrain is taking its place as the fourth active participant in this battle and woe to whoever ignores it.

The Syrian breaks again at the right time and place and I pull above him, stronger and faster but still unable to get a good shot. He flies, that man, lower than I have ever seen, knows where to look and when, has excellent vision, and has the concentration and the attention to fly on the deck, to think clearly, to judge correctly when to do what, and not to make any mistakes. He flies very well, that man, not only by the criteria of the Arab air forces but by any criteria, and I am beginning to understand that we have found a real adversary, as good as any we have ever fought, and that this battle will be quite different.

It seems reasonable to assume that about this time a similar thought occurred to the Syrian. I could almost visualize the Syrian casting away all the approved rules and remaining alone with his machine without standard operating procedures, without do's and don'ts, without all he had been told until today—rules only applicable to pilots not as good, and situations not as desperate.

This is not the way to fight. This is not what I had taught others. One must not fly at such levels of risk that only success separates them from recklessness. But something told me, with great certainty, that today and with this man this was the only way, and that it was out of the question that he would return home alive and boast at the club that he had been jumped by two Mirages and escaped unscathed because he flew at an altitude which was too low for the Jews and they were afraid to follow.

To this day I do not know whether I did the right thing, and there is no one to tell me either. I do not remember the surrounding terrain except as a collection of obstacles and opportunities. The entire periphery is etched in my memory as an express tunnel of eight and a half minutes with a series of entries and pull-outs, three volleys which missed, and extremely hard physical effort. Remarkably, that part of the brain that had to do the planning, the decision-making, and the judgement was all right, and knew the difference between the risky but correct action and the mistake. In spite of its wild nature, the battle was free of mistakes—both on our part and on the Syrian's.

I remember him at least once at the bottom of my gunsight, which I could not lower further by even one millimeter because we were already among the treetops and he was a couple of agricultural terraces lower than I was. I remember checking my fuel at regular intervals, and checking that I had not picked up unwanted company on my tail, and being careful about keeping the correct speeds, and jettisoning the center external tank just as it ran out of fuel. And I remember a few radio coordinations and watch-your-sixes with Amos who was, I think, as hot as I was. I remember the Syrian pulling up after me once and both of us climbing out of the valley in cold rage. I remember Amos, who was watching over me, saying, "Watch out, he is coming after you!" and I, more alive and aware than I had ever been, knowing exactly how much speed the man in the MiG had on his gauge and that he was bluffing. I remember my heavy breathing and the rolling perspiration and my beautiful Number 19 staying with me, powerful and smooth and strong and eager for battle.

And so we kept getting further and further north, three madmen joined together till death do us part . . . .

The missile on my wingtip, a Sidewinder-B from America, sends a buzz through my headset from time to time to inform me that it "sees" the MiG, but I know missiles inside and out and on this particular type I did some of the flight testing and I know exactly its flight curve and how the steering balances gravity. I know that I must not launch at this altitude because the missile will simply dive straight into the ground, directly in front of me, if I do not provide it

with some room to sink before it has a chance to start homing and climbing.

For a long time I ignore it and rightfully so until, during one of the climb-outs, I see that the MiG is about to cross a wide valley at right angles. The man in the MiG does not know this yet, because all he can see from his altitude is the near ridge before the valley, and Amos is almost in firing range already and the Syrian must get busy again and break nicely and correctly among the treetops. So this is my chance. In that wide valley the missile will be able to sink

and I need to time it so that it will complete the low part of its flight path inside the valley and then will be able to climb and hit the MiG before the Syrian crosses the ridge on the far side.

I do not descend toward the MiG. Instead, I stay at altitude and close the range to 800 meters, the very heart of the missile's flight envelope, and I see the MiG's silver, fish-like silhouette evading Amos' Mirage once again and twisting northward, homeward. The MiG is skimming the rocks, following a narrowing valley that is turning into a dry river bed, climbing within its walls to the top of the ridge.

Now!

With the sight on the distant tailpipe, I hear the missile's battle cry at once. Before the Syrian has a chance to notice that the ground is about to fall away from under him, I launch. A sharp "whoosh!" from the wingtip and the missile is on its way. It is flying, twisting, and aiming toward the top of the ridge and toward the black tailpipe crossing it . . . .

The MiG crossed the ridge first. What thought flashed through the Syrian's mind when he saw the protective ground fall away, not to return until the other side of the valley? Perhaps he did not think about it at all, or perhaps he thought [he could reach the other side of the valley before Amos or I could come into range].

The missile crossed the ridge successfully, still sinking, two seconds later, registering a new world record for low-altitude flight by a missile. It continued to sink some more in the valley before it started climbing, homing steadily on the MiG, advancing fast and about to score a hit.

Something caused the Syrian to do the very last thing in his life. Perhaps he saw the distant portion of the missile's smoke trail, perhaps he grew suspicious. No one will ever know. When the missile was about 50 meters behind him, the man began a break to the right, still within the valley. It was too close and it was too late. The missile tracked with ease, armed its twenty-pound warhead, and disappeared beneath the descending right wing.

After that everything happened at once, but not quite. The last second of the brave and talented man's life is still etched in my memory: the missile with its thin smoke plume hiding beneath the wing; the large orange flash which was almost certainly a direct hit; the right wing breaking at the root; the fast, uncontrolled roll toward the missing wing; the grotesque spin of the stubby fuselage. Then came the unavoidable crash of the broken MiG into the distant, steep wall of the valley and the ugly, black mushroom that sprouted from the green terrain.

It was quite far, maybe 700 meters away. Perhaps that is why the victory and the Syrian's death seemed secondary to the experience of the battle, a disappointing finale to the struggle, and I do not remember any glee, not at the moment of victory and not during the long flight home, only real fatigue and drying perspiration.

I did the victory roll over the Squadron almost mechanically, then landed with the concentration of a student pilot and taxied to the parking area. I secured the engine, turned off all switches, undid the harness, and attempted to climb down from the cockpit to the small, happy crowd of mechanics, clerks, and pilots, when I realized I needed all my strength just to stand up from the seat and that the legs underneath the soaking wet G-suit were not mine.

There were debriefings and we saw the film and there were some stirrings in the room when the trees appeared on the screen at the same altitude. I do not remember much of these. Then the word came that it had been determined who the man was; a well-known colonel, an outstanding pilot. It was said that he had a state funeral in Damascus and that he was promoted posthumously and I knew, as one knows only the important things, that he was deserving of both. Then the word came that perhaps not—perhaps that colonel had been felled that same morning at the hands of another pilot, and the man I met near Mount Hermon was someone else, an unknown. All we know now is that we do not know, and that it does not matter.

The man in the MiG. A famous hero or an unknown just starting to blossom, he was deserving of one more thing, and to this day I hope that it was granted him. I hope that he died instantly when the missile hit and did not live that last second and never, never knew that he lost the battle.

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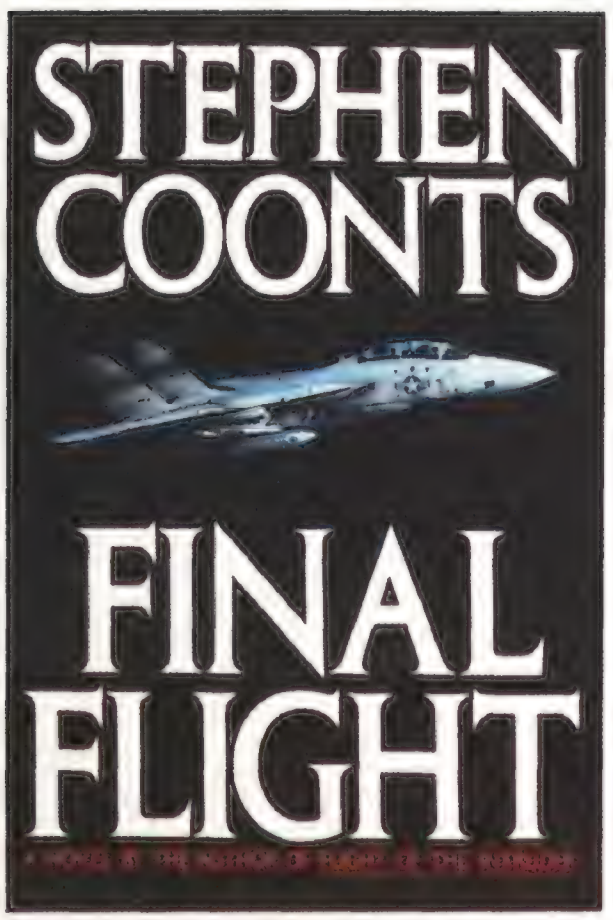


***Final Flight** by Stephen Coonts. Doubleday, 1988. 376 pp., $18.95 (hardbound).*

Nuclear theft has been a mainstay of thriller novels ever since the bad guys stole a British bomber in Ian Fleming's *Thunderball* and threatened to obliterate Miami with its A-bombs. Aircraft and nuclear weapons are again at stake in *Final Flight,* but author Stephen Coonts has added a chillingly credible twist: here the thieves are Arab terrorists, and the scene of the robbery is a U.S. supercarrier patrolling the Mediterranean.

Coonts, who flew A-6 Intruders from the carrier *Enterprise* during the Vietnam War, uses several of the elements that distinguished his first novel, *Flight of the Intruder.* Hot-blooded Navy lieutenant Jake Grafton, the hero of *Intruder,* has been promoted to air wing commander when *Final Flight* begins. Events of the intervening 16 years—notably his marriage to Callie McKenzie—have mellowed the warrior in Jake somewhat, but he still chafes at the narrowly defined rules of engagement that limit the Navy's combat options. *Final Flight,* like *Flight of the Intruder,* shows Jake bending those rules in spectacular fashion.

Jake's carrier, the *Nimitz*-class *United States,* holds enough destructive power in her magazines to wipe a small country off the map. The *United States* therefore proves an irresistible target to El Hakim, tyrant of an unnamed North African nation obviously patterned after Libya. Fed up with his footnote role in history, El Hakim grows determined to get his hands on some nuclear bombs and "force the world to its knees."

The instrument of El Hakim's will is Colonel Qazi, master of seven languages and innumerable disguises. Qazi rounds up a terrorist's Dirty Dozen that includes a blackmailed U.S. nuclear weapons expert, a publicity-hungry PLO officer, a fugitive CIA agent-turned-arms merchant, and, for good measure, a bisexual belly dancer.

No less eclectic is the range of illicit activities the author details. We learn everything from how to bypass the safeguards in a nuclear bomb (carefully) to how to dress for an amorous encounter in the trunk of a moving limousine (sparingly).

Such diversions aside, the most powerful part of *Final Flight* is its richly drawn portrait of carrier aviation. Coonts served as a catapult officer aboard the carrier *Nimitz* following his tour of duty as a pilot, and he eloquently renders that experience in passages describing the carrier's "launching ballet": "It looked like utter chaos," reflects Jake as he awaits a catapult launch, "this little army of men in their different-colored jerseys surging to and fro around the moving planes, but the steps and gestures of every man were precisely choreographed, perfectly timed." Nor does Coonts neglect the visceral thrill of the launch itself or the drama that begins at the end of that three-second slingshot ride.

When it falls to Jake to thwart El Hakim's diabolical final design, the Navy's new high-performance F-14D Super Tomcat and its weaponry come in handy: Coonts portrays the Navy's aerial arsenal—Harpoon air-to-surface missiles, Rockeye bombs able to "penetrate nine inches of cold-rolled steel," and Phoenix, Sparrow, and Sidewinder air-to-air missiles—with a depth of research that rivals the best of Tom Clancy's hardware catalogs.

Ultimately, however, it is the lyrical rather than the technical passages that propel *Final Flight* above the high-tech thriller genre. At one point Jake is moved to rhapsodize about "the flying, the flying—the stick in his right hand and the throttles in his left, the rudder pedals under his feet, soaring as he willed it with the engines pushing—the flying was pure and clean and truly perfect."

Though purity and cleanliness are far removed from the harrowing chain of events that Coonts has imagined in *Final Flight,* the novel succeeds in providing truly perfect entertainment.

—Allan Fallow is an editor at Time-Life Books.

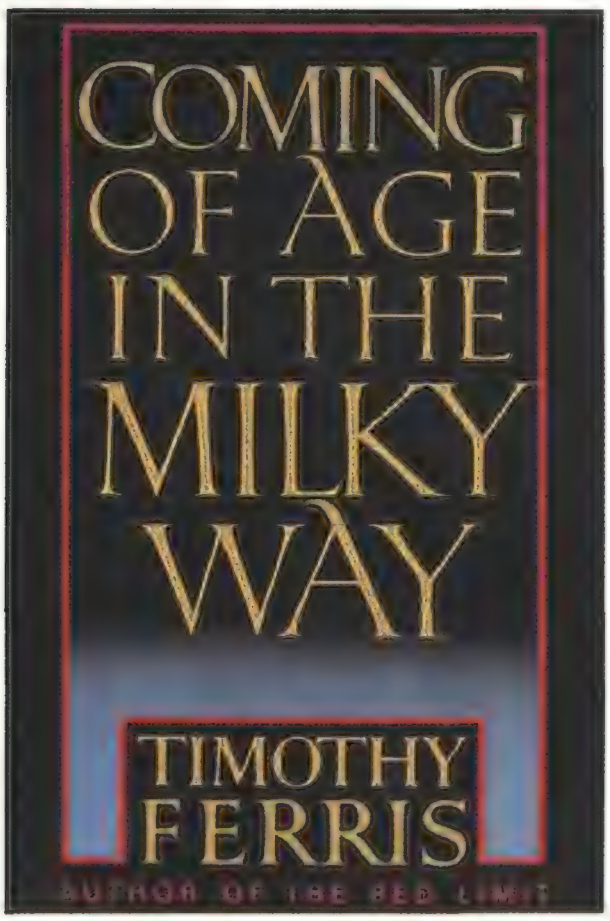
***Coming of Age in the Milky Way** by Timothy Ferris. William Morrow and Co., 1988. 495 pp., b&w illustrations, $19.95 (hardbound).*

Coming of Age in the Milky Way is an ambitious book, its scope nothing less than a complete history of the process by which we human beings have acquired our present knowledge of the universe and our place in it. Starting with the Greeks, the author takes us through the work of Galileo, Newton, Darwin, and up to modern concepts such as the inflationary universe and the search for extraterrestrial intelligence.

Ferris' 1977 book *The Red Limit* has become a classic of science exposition, and many of the threads of thought that run through it appear in *Coming of Age* as well. What gives human beings, occupying an insignificant piece of rock orbiting an ordinary star in the low-rent section of a run-of-the-mill galaxy, the confidence to look outward and measure the heavens?

How has our ability to do so depended on advances in scientific technique and mathematical insight over the past two millennia? The story has been told often, but it's a good one that bears retelling.

The strong point of the book is Ferris' ability to portray personalities, to show science as a human endeavor. Too many people think of science as a kind of industrial enterprise carried out by men and women who are little more than robots, and *Coming of Age* does a good job of



showing how false this notion is. I particularly enjoyed Ferris' account of how Galileo, ever the hustler, conned the rulers of Venice into believing that he had invented the telescope—at the very moment that a shipload of the new instruments was on its way from Holland, where they had actually been invented and were already being mass-produced. In contrast, Ferris manages to paint a sympathetic portrait of Isaac Newton, surely one of the most unlikable of geniuses to find a place in the history books.

Clearly, Ferris has expended a great deal of effort in pursuit of scholarship and accuracy: the book is heavily footnoted, and the notes and bibliography occupy over 60 pages. I am sorry to say that the results of his research are not always up to the standards set by his writing.

He quotes without comment, for example, an account of the death of the female mathematician Hypatia of Alexandria that was written centuries after the event and is almost surely fictional. It's a good quote, but surely a warning to the reader would have been appropriate. In his discussion of the birth of modern geology, he perpetuates what Harvard paleontologist Steven Jay Gould calls "cardboard history" by setting up straw men—in this case the catastrophists—to contrast with the all-too-obvious good guys—the uniformitarians. (The catastrophists argued that the Biblically derived 6,000-year age of the universe is consistent with the fossil record because the earth could have changed radically after any number of catastrophes, while the uniformitarians held that the earth and its creatures have evolved gradually and continually over millions of years.) This oversimplifies a complex piece of history and sheds little light on the way that science really works.

I enjoyed this book, so I found these lapses troublesome. They may be only isolated weaknesses, but finding them made me nervous. I would recommend reading *Coming of Age in the Milky Way* for enjoyment, particularly for its wealth of human detail. Ferris' style makes it easy to read, even when the topic turns to concepts in modern cosmology that are difficult to grasp. I would, however, keep a small reserve of skepticism about the accuracy of the historical details.

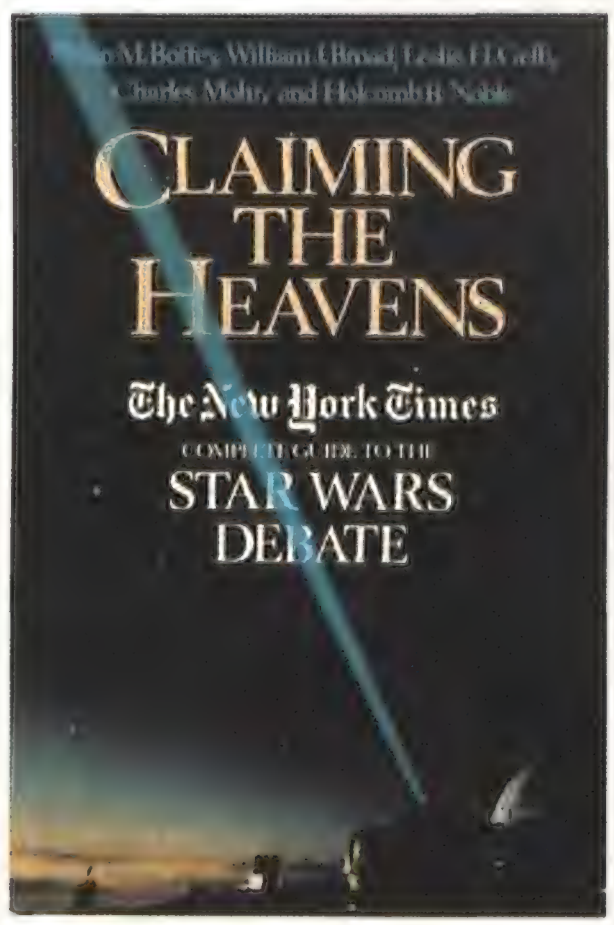
—James Trefil is Clarence Robinson Professor of Physics at George Mason University in Virginia. His latest book is The Dark Side of the Universe.

***Claiming the Heavens: The New York Times Complete Guide to the Star Wars Debate** by Phillip M. Boffey, William J. Broad, Leslie H. Gelb, Charles Mohr, and Holcomb B. Noble. Times Books, 1988. 299 pp., b&w photos and illustrations, $17.95 (hardbound).*

For the past five years the controversy over President Reagan's Strategic Defense Initiative has dominated the public debate over arms control and nuclear weapons policy. The story of Star Wars, as the program is popularly known, is a complicated one, full of obscure technical developments and new political twists. The staff of *The New York Times* has consistently provided the best coverage of this saga, earning a Pulitzer Prize in the process. *Claiming the Heavens* encapsulates the paper's reportage to date.

The authors trace Reagan's interest in strategic defense to his formative years as a B-movie actor, and they chart the growing effort to put strategic defense back on the national agenda. The wisdom of deploying major anti-missile systems was heatedly debated in the 1960s, and then in 1972 the Anti-Ballistic Missile Treaty ended discussion among laymen by forbidding such systems. Within scientific and aerospace communities, though, interest in anti-missile defenses remained high. These two story lines converged and culminated in Reagan's surprising March 1983 speech proposing the Strategic Defense Initiative.

The authors provide an accessible and balanced description of the technical challenges posed by defense against



ballistic missiles, as well as the prospects for meeting these challenges. But they correctly note that the heart of the Star Wars debate is political, rather than technical. "Most of the public debate about the Strategic Defense Initiative seeks to resolve itself on the issues of scientific and technical feasibility. [But there is also] a different debate. This is an argument on the strategic worth of ballistic-missile defense and on its actual military . . . utility."

As an active participant in this controversy and no stranger to the pages of *The New York Times,* I have concluded that deployment of a strategic defense system would not be in the national interest. But I cannot entirely disagree with the authors' conclusion: "What is unclear, and will probably remain that way for years to come, is whether the new weapons will be defensive or offensive, whether they will make the world safer or more dangerous, whether they will render nuclear weapons impotent and obsolete or will simply add costly impetus to the arms race."

The nation still has not made an

irrevocable commitment to the Strategic Defense Initiative, and as the Reagan presidency draws to a close the future of the program is in doubt. But reports of the death of Star Wars have been greatly exaggerated. Although their technological achievements have been meager, advocates of SDI have succeeded in once again making strategic defense a real issue for political debate. Thus, *Claiming the Heavens* should be read not as the history of an era drawing to a close but as an episode in an ongoing drama.

—John Pike is the associate director for space policy at the Federation of American Scientists.

***Air Traffic Control Simulator** by HJC Software. For Macintosh 512, 512E, Plus and SE. $49.95.*

This is not easy. Sure, you can simplify things by handling the minimum number of airplanes in the maximum amount of time. Or you can get rid of the thunderstorms that march across the simulated radar screen, costing you points every time one of the flights under your control blunders into one. And you could de-select the hills,

obstacles, and restricted areas that make your life as an air traffic controller difficult. But then, where's your self-respect?

The software's graphic presentation provides you with a very simplified semblance of a real controller's work station, including a radar map of your area and a schedule of flights to be handed off to you as they enter the radarscope's area or take off from the airports you control.

A schedule running down one side of the screen counts down the minutes and seconds until an airplane comes at you from one of eight compass points. Takeoffs are announced, but you can hold an airplane at the airport if the pressure mounts. You command turns of 45-degree increments and assign altitude changes using symbolic keys. The aircraft—jets, props, and helicopters—respond, but with certain limitations: they can change altitude no faster than 1,000 feet every 15 seconds, and direction changes have to be anticipated so that each craft will turn onto the track you want.

It's the anticipation and the ability to seize and hold a mental picture of the changing pathways of a number of craft that make the real job of controlling air traffic such a challenge. What you won't be prepared for is how easily this seemingly innocent little game can get to you. Nothing in this world can equal the rising panic that grips you when you first sense that your control of the situation is slipping. Under the most difficult conditions you can impose, it is possible to score 240,000 points. If you set that as your goal, make sure medical help is nearby.

The program is written in LightSpeed Pascal, and in about a dozen sessions I couldn't find any bugs. The radar sweep is jumpy and erratic, so switch it off. And the manual is less than clear about how to land an airplane (a landing has to be commanded when the airplane is on its approach to an airport, not at the airport itself).

HJC Software says the simulation game has broad applications in teaching air traffic control, and the software certainly could prove useful in screening applicants for aptitude. But how would a professional controller respond when his computer informs him that his "incompetency" has caused a crash? "You have been given two career choices," the message continues, and there are two boxes outlined below: "Resign" and "Be fired."

Dial up the difficulty and spend a one-hour shift testing your skills. You'll come away from the experience a little bit sadder but a whole lot wiser.

—George C. Larson is the editor of Air & Space/Smithsonian.

"The Satellite Sky" Update/9

These regular updates to **"The Satellite Sky"** chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

Deletions

90 to 300 MILES

Cosmos 1646
down 5-12-88

Cosmos 1942
down 7-4-88

Cosmos 1944
down 6-24-88

Cosmos 1951
down 6-14-88

Cosmos 1952
down 6-25-88

Soyuz TM-4
down 6-17-88

Launched but not in orbit

90 to 300 MILES

Cosmos 1956 USSR photo recon	6-23-88	down 7-9-88
Cosmos 1957 USSR earth sensors	7-7-88	down 7-21-88
Progress 37 USSR research	7-18-88	down 8-12-88
PRC 23 China research	8-5-88	down 8-13-88

Inoperative but still in orbit

300 to 630 MILES

Cosmos 1850

Cosmos 1892

6,200 to 13,700 MILES

Cosmos 1778-80

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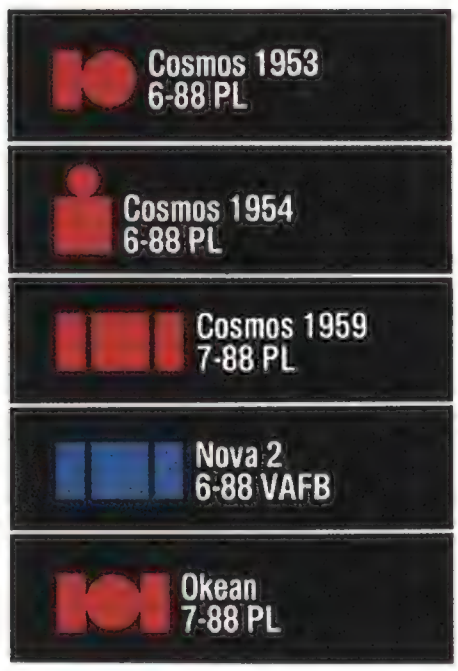
New launches

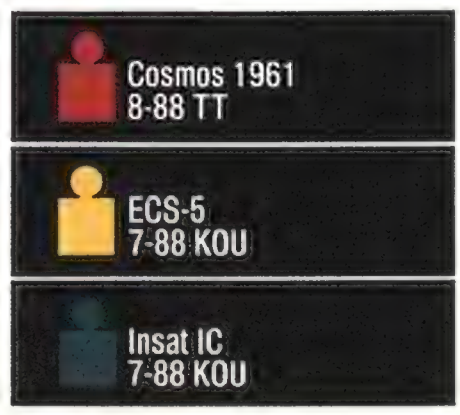
90 to 300 MILES

300 to 630 MILES



630 to 1,250 MILES

21,750 to 22,370 MILES



Credits

No Joystick in the White House? Carl A. Posey is an editor at Time-Life Books. Being a pilot, he has not sought the presidency.

Shadow Boxing. J. Kelly Beatty is senior editor at *Sky & Telescope.*

Pilot Playground. Patricia Trenner is departments editor at *Air & Space/Smithsonian.*

A pilot for 15 years, photographer James Sugar flies a Cessna Skyhawk. He is a frequent contributor to *National Geographic* and *Air & Space/Smithsonian.*

The Space Statesman. Nicholas Daniloff is a Resident Fellow at Harvard's Shorenstein Center for Press and Politics. His book, *Two Lives, One Russia* (Houghton Mifflin, 1988), tells the story of his arrest and imprisonment by the KGB while he was a Moscow correspondent for *U.S. News & World Report.*

High Society. Doug Stewart is a freelance writer in Newbury, Massachusetts, who writes frequently about space and technology.

Alan E. Cober has won 11 gold medals from the Society of Illustrators. He is a professor of art at the State University of New York in Buffalo.

United's Crystal Palace. A longtime Washington, D.C. art critic, Frank Getlein is a frequent flier who is frequently delayed. His article "Flight Fantasia" appeared in the December 1986/January 1987 issue of *Air & Space/Smithsonian.*

"The Hitherto Impossible in Photography Is Our Specialty." Simon Baker is a professor of geography at East Carolina University in Greenville, North Carolina. His fascination with Lawrence's photograph of San Francisco led to a 10-year study of the photographer and his techniques.

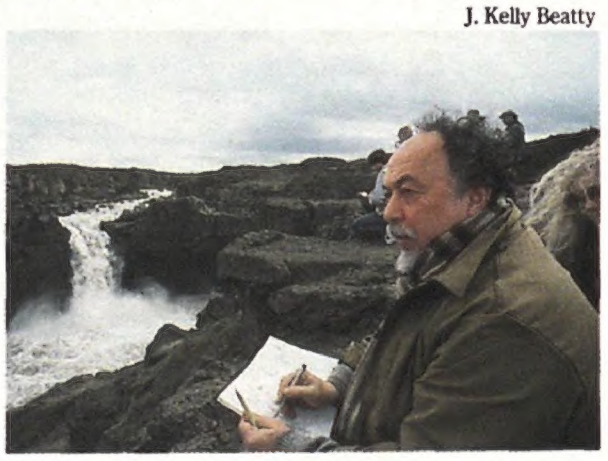
A Spaceship Named Orion. Bill Wagstaff has written for many aviation and business publications, including *Aviation International News* and *Dun's Business Month.*

The Lear Fan Saga. T.A. Heppenheimer has written articles for *Omni, Science Digest,* and *High Technology.*

Poster: The Jet Set. Martha M. Hamilton is a *Washington Post* reporter who covers transportation and energy.

In the Wings . . .

J. Kelly Beatty

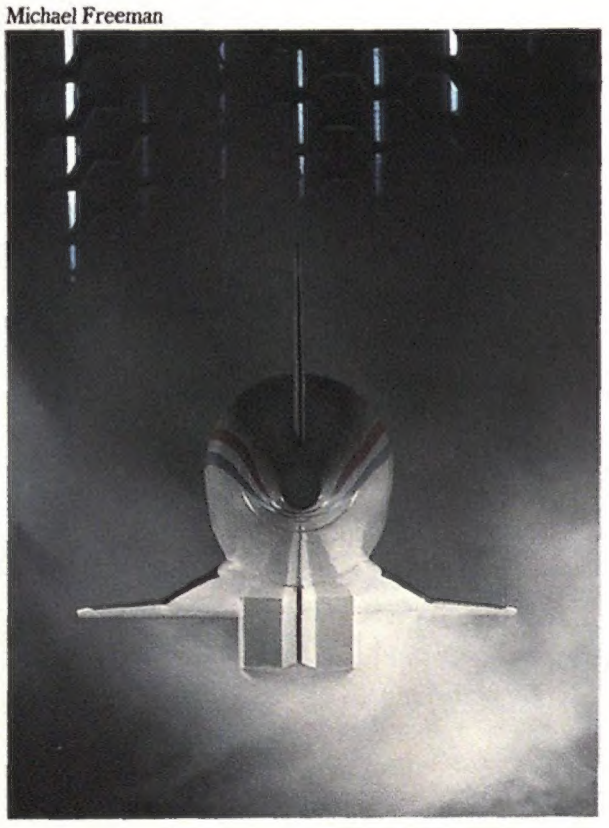


Art on the Rocks—Where on Earth can a space artist go to paint an extraterrestrial landscape? A group of Soviets and Americans found what they needed in Iceland, an island with otherworldly terrain.

Spacecraft, Hollywood Style—Some experts figuratively kick the tires of three vessels from the movies.

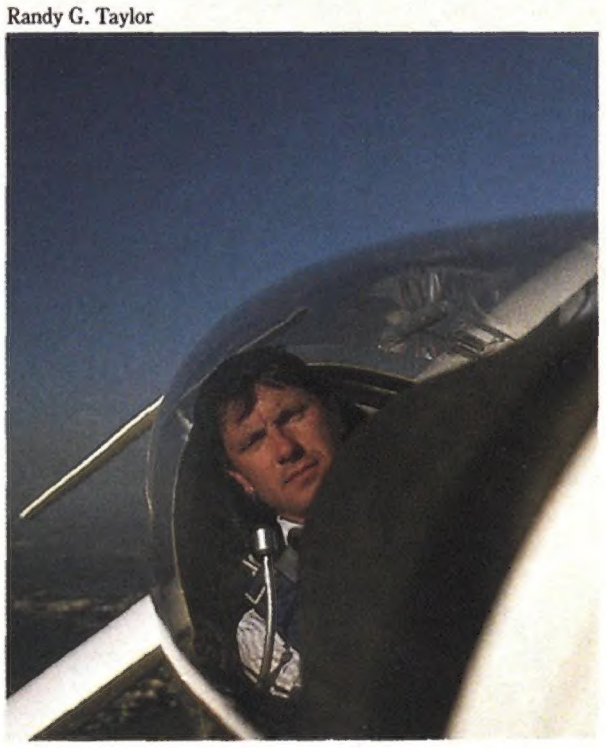
HOTOL Dreams—British space plane designer Alan Bond wants to see his dream take wing—but his government refuses to chip in another pound.

Michael Freeman



Soaring's Superbowl—The crowd's a lot smaller but the competition's just as fierce when the world's best sailplane pilots vie to become the Master of Soaring.

Randy G. Taylor



Flights & Fancy—Back when Ann Hood was spending her days writing and her nights flying, no one wanted to hear about her life as a stewardess. Then her first novel became a best seller, and suddenly everybody did.

Border Patrol—The battle to control illegal immigration from Mexico has taken to the air.

What Made the X-1 Run?—It took a special engine to punch Chuck Yeager through the sound barrier.

Io's Inferno—This Jovian satellite, the only other world in our solar system with active volcanoes, may teach scientists some lessons about our own planet. A spacecraft named Galileo will provide the text.

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